

Investigation of Parametric Evaluation of Gray Images

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ABSTRACT: Image enhancement is one of the most powerful techniques that has been developed and applied worldwide for the manipulation of the images to be applied for any particular use. There are many factors due to which errors creep into an image. The principal objective of image enhancement is to remove the errors and bring out the hidden details which is obscured or to highlight any portion that can be used by any machine or for any human analysis. There are many fields such as medical, defense, geology, astronomy, robotics, remote sensing, digital photography and climate study where this technique is implemented on a large scale. Image enhancement makes use of various functions to alter an image and make its meaning clearer to a human observer or for any specific use. In this paper, we have presented a review of the various image enhancement techniques such as the histogram equalization and image adjustment. We have also included the comparison results using PSNR and SSIM as parameters. All the simulations and the results used have been performed on grayscale images in the MATLAB environment.

KEYWORDS:

Image enhancement, Histogram equalization (HE), Image adjustment, Mean square error (MSE), Peak signal to noise ratio (PSNR), Structural similarity index matrices (SSIM)

1) INTRODUCTION

A) IMAGE ENHANCEMENT

Image enhancement is one of the most important and the appealing domains in the field of multimedia applications. It is applied in the cases of the digital image which are captured with the help of the digital devices. . The use of the digital electronic devices is increasing as the days pass by due to which there is a need for image enhancement. This in turn increases the employment in this domain [3]. When any image is captured on a device or transferred from one device to another, then it faces some loss of the information [1]. These errors in the image creep into the image because of storage, transmission, color inversion, compression and decompression or sent by internet or modified which thereby affect the quality [1]. Also, due to the noises which enter into an image and deteriorate the quality of the image. To remove such errors in the said image and obtain the original image the image enhancement technique is employed. It is such a technique which helps the user to remove the unwanted portions and improve the clarity of the image. It helps to introduce some unnatural artifacts that increase the brightness or the contrast of the image [1]. The main objective of this technique is to improve the visual quality of the image that can be easily understood by a human or for inspection by a machine [4]. Also, it is used to highlight the hidden or the minor parts of the image from where the important information can be recovered. It does so by increasing the dominance of some parts of the image required [4] and reducing the intensity in other parts of the image and by increasing the contrast of a low contrast image or by modifying the pixels. This technique finds its applications in a large number of fields of which the most important is in the medical sciences. The most ones are the remote sensing, computer tomography [1], astronomy, defense forces and in satellite imaging. In medical sciences, it is widely used to observe and study the tumor, cancer detection, ultra sonogram, MRIs and CT scan. In satellite imaging, it is employed to remove the unwanted noises in the image captured to observe all the information in the captured image.

In this paper, we will employ the various tools of MATLAB such as the histogram equalization and the image adjustment functions.

B) ABOUT MATLAB

The word 'MATLAB' stands for Matrix Laboratory which is owned by MathWorks. It is very popular software among the engineers and the technicians of the various fields such as in robotics, automation, measurements, modeling and implementations in other subjects such as chemistry, biology, mathematics and many more. The reason behind its popularity is because of the range of facilities it provides on a single platform. It is a user friendly environment which integrates graphics, coding, signal processing, image processing, complex numeric calculations and visualization which include mathematical notations. Its most important feature is its way of representing the data in which it employs matrices. It is the most often used software higher

education for advanced courses in Mathematics, Engineering & Science. In Industrial domain it is the best choice for high productivity research, development and analysis. [2]

The features include:

- 1) It is a high level language that is usually used for technical computing.
- 2) It provides a development platform for managing codes, files and data.
- 3) It can give a 2D and 3D representation of data.
- 4) It has got inbuilt tools for building the respective GUIs (Graphical User Interface).

2) METHODOLOGY ADOPTED

a) HISTOGRAM EQUALIZATION

i) OVERVIEW

Histogram equalization is one of the most widely used techniques for image enhancement. It is widely used because it can be applied very easily and method of working is also very simple [1]. After getting the original image, it starts flattening and stretches the dynamic range of the resultant histogram as a result of which it increases the overall contrast of the original image [6]. It works on the principle that it remaps the gray level of an image based on the cumulative density function up to the input gray level regardless of the input gray level ([6] & [1]). This method is a global method which means it can increase the overall contrast of the image. The high performance of the histogram equalization is in enhancing the contrast of an image is due to the dynamic range expansion [1]. There is also an unnatural enhancement in most part of the image. This is due to the excessive change in the brightness by it when the image has a high density over high gray levels. It defines the neighborhood and moves the centre of this area from pixel to pixel [4]. By using the previous histogram it generates the new histogram.

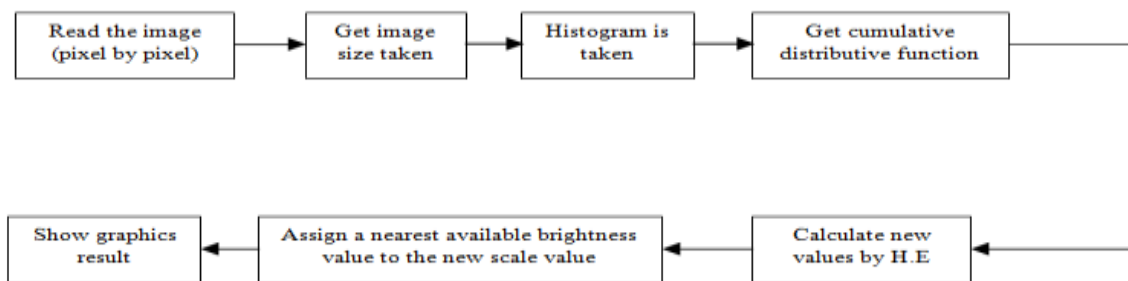


Figure 1: Block diagram of HE

ii) ADVANTAGES

It is a straight forward function and is an invertible operator. If one knows the histogram equalization then the original histogram can be easily recovered. It is very simple and can be used to increase the contrast of the image.

iii) DISADVANTAGES

If in some part of the image, there are gray values which are far apart from each other then this function cannot be used and does not take the mean brightness of the image into account [7]. It introduces excessive brightness because of intensity saturation effect. Also, it causes excessive brightness in the image thereby the output image contains very dark or very bright intensity values. Due to this, it is not employed in electronics devices such as cameras, television and many more [1]. It produces significant noise in the image because it tries to amplify noise [8]. In television, it is not used because of the two disadvantages which include over enhanced high frequency gray level image and loss of contrast in low frequency gray level image region [6].

iv) TYPICAL HISTOGRAM EQUALIZATION

For an image X , the probability density function (X_k) is given by:

$$p(X^k) = \frac{n^k}{n} \quad (1)$$

For $k = 0, 1, \dots, L-1$ where n_k represents the number of times that the level X_k appears in the input image X and n is the number of samples in the input image.

Here, $p(X_k)$ is related to the histogram of the input image which shows the number of pixels that have a specific intensity X_k . Actually, a plot of n_k versus X_k is the known histogram of X .

Based on the probability density function, the definition of the cumulative density function can be given as:

$$c(X) = \sum_{j=0}^k p(X_j) \quad (2)$$

Where $X_k = x$, for $k=0, 1 \dots L-1$. It must be noticed here that $c(X_{L-1}) = 1$ by its definition. Histogram equalization is a scheme that maps the input image into the entire dynamic range, (X_0, X_{L-1}) , by making use of the cumulative density function as a transform function. Let define a transform function $f(x)$ based on the cumulative density function as:

$$f(x) = X_0 + (X_{L-1} - X_0)c(x) \quad (3)$$

Then, the output image of the Histogram equalization can be given by:

$$Y = f(x) \\ = \{f(X(i, j)) | \forall X(i, j) \in X\} \quad (4)$$

b) IMAGEADJUSTMENT

Imadjust () is a function of MATLAB which is basically used in digital image processing, this function adjusts the image intensity i.e. it increases or decreases intensity of image. This process is carried out by the help of gamma parameter which changes the shape of the curve mapping of the image. Actually, value of intensity can be modified by changing this gamma parameter. Imadjust () maps the values in intensity of input image to new values in output image. Thus, contrast of output image is increased with respect to the input image [3].

The Advantage of this function is that the output image is more clear and appropriate.

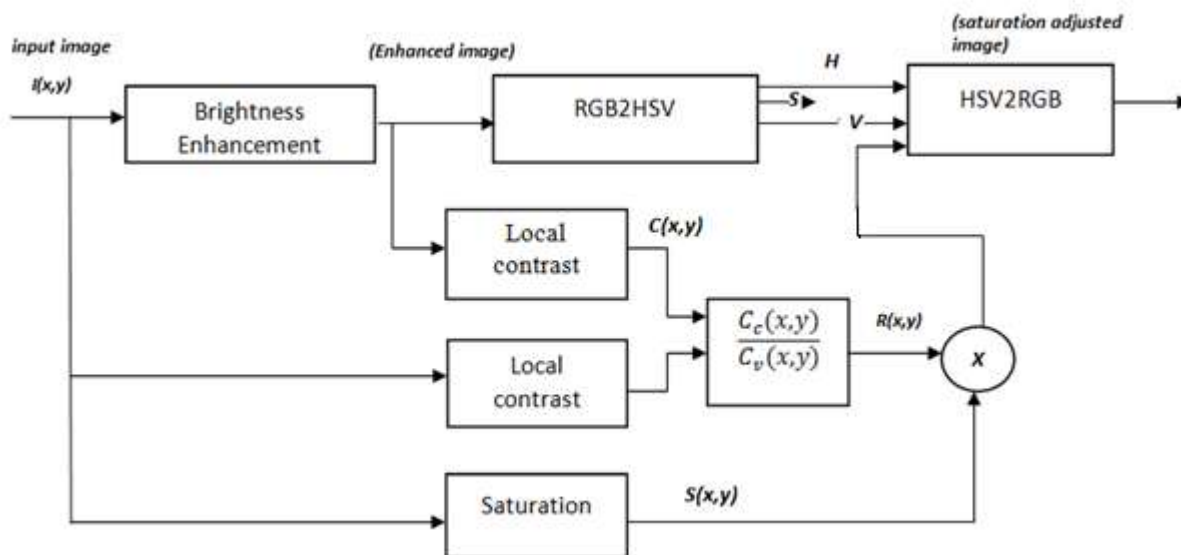


Figure 2: Block diagram of image adjustment

c) PARAMETERS USED FOR EVALUATION

i) PSNR (PEAK-SIGNAL-TO-NOISE-RATIO)

i.1) OVERVIEW:

Peak-signal-to-noise-ratio often called as PSNR, is an engineering term which is very often used and most understandable metric as a quality measurement between the original and an enhanced image. It is actually a mathematical measurement of image quality based on the pixel difference between two images usually the original image and enhanced image [9].

It is also defined as the maximum possible power of a signal and the power of distortion of the images. Alternatively, PSNR is most easily defined via the Mean Square Error (MSE) which represents the cumulative squared error between the original and enhanced image [10].

i.2) ESTIMATION OF PSNR:

To calculate PSNR, first we must calculate MSE. So, MSE of a given noise free $m \times n$ monochromatic image I and it is a noisy approximation K [1],

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2 \quad (5)$$

The above equation shows that higher the value of MSE higher will be the quality of the enhanced image.

Now to calculate PSNR (in dB) by,

$$PSNR = 20 * \log_{10}(MAX_I) - 10 * \log_{10}(MSE) \quad (6)$$

Here, MAX_I is the maximum possible pixel value of the image.

For an 8 bit monochromatic image, the typical value of PSNR is 30 to 50 dB and 60 to 80 dB for a 16 bit monochromatic image [9].

i.3) ALGORITHM FOR PSNR ESTIMATION:

Step 1: Start the program.

Step 2: Read the image from the folder.

Step 3: Find the pixel and Mean Square Error (MSE) of the image.

Step 4: Build new image by replacing original gray values with new gray values.

Step 5: Find the pixel and Mean Square Error (MSE) of the new image.

Step 6: Calculate Peak-Signal-to-Noise-Ratio (PSNR).

Step 7: Show the result in form of ratio.

Step 8: Stop.

i.4) SCHEME OF THE PSNR ESTIMATOR [11]:

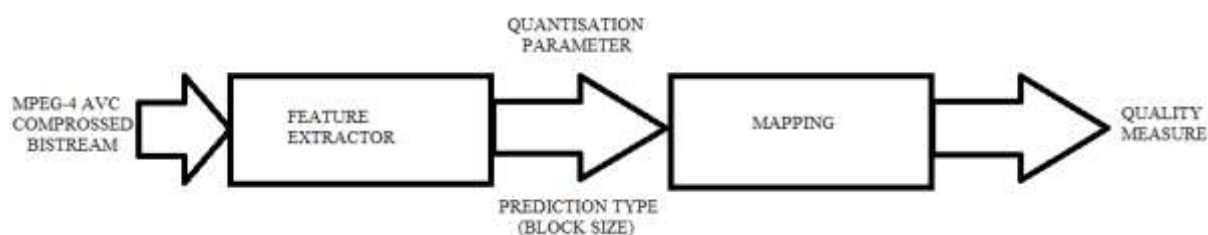


Figure 3: PSNR estimation

i.5) ADVANTAGES & DISADVANTAGES:

The advantage of PSNR is that we can obtain a compared result between the original and the enhanced image is obtained. Besides, it also gives a quality measure between the original and the enhanced image. It is a quality measure memory.

The main disadvantage is that it does not give perfect information about perceived quality.

Serial no	Name of the image	Size of image (pixel)	Original image	Enhanced image(using imadjust)	Enhanced image(using histeq)
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ii) SSIM (Structural Similarity Index Matrices):

Image enhancement is one of the most important things in the territory of the image processing.

Image quality is a characteristic of an image which measures the real image degradation. There are two types of image processing subjective quality assessment and objective quality assessment. Objective quality assessment is mathematical model that make an approximation of subjective quality assessment. SSIM is one of the types of objective quality assessment. The known matrices unlike PSNR and MSE are not appropriate with the visual system of a man .So the command SSIM is designed to uplift the image processing based on the conception of human visual system. The STRUCRURAL SIMILARITY INDEX abbreviated as SSIM is depended on visible structures of images. It is the command by which we can measure the perceptual difference between the two analogous images .It requires two images the original image and the processed image and the processed image will be compressed. The SSIM algorithm is founded on pixels of an image having strong dependencies. These dependencies are used to carry important data about the formation of a scene. Thus, this way that is able of measuring the changes in the structural data which provides exactness in perceived image distortion. The main advantage of the SSIM algorithm is to identify the degradation of the image as perceived change in structural data ([12] – [13]).

And the equation of SSIM is:

$$SSIM(x, y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)} \quad (7)$$

Here, μ_x is the average of x, μ_y the average of y, σ_x^2 the variance of x, σ_y^2 the variance of y, σ_{xy} the covariance of x & y







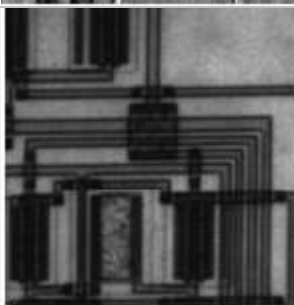
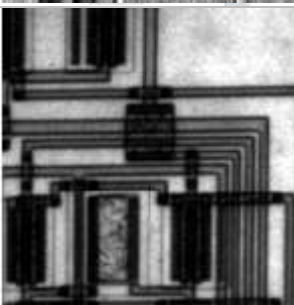
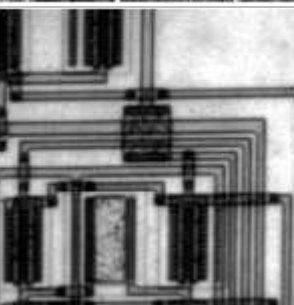



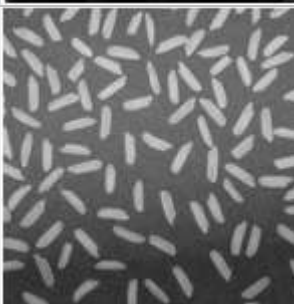
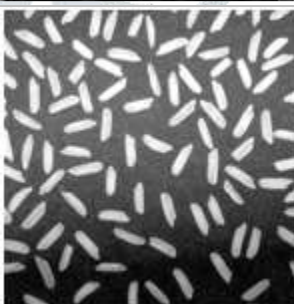

Formula components:

The SSIM formula is based on three comparisons measurements between the samples of x & y: luminance (l), contrast(c) and structure(s). The individual comparisons functions are:

$$l(x, y) = \frac{2\mu_x\mu_y + c_1}{\mu_x^2 + \mu_y^2 + c_1} \quad (8)$$

$$c(x, y) = \frac{2\sigma_x\sigma_y + c_2}{\sigma_x^2 + \sigma_y^2 + c_2} \quad (9)$$

$$s(x, y) = \frac{\sigma_{xy} + c_3}{\sigma_x\sigma_y + c_3} \quad (10)$$

1	pout.tif	291x240			
2	cameraman.tif	256x256			
3	circuits.tif	280x272			
4	tree.tif	258x350			
5	rice.tif	256x256			

3) RESULTS:

FIVE IMAGES HAVE BEEN TAKEN FOR PARAMETRIC ANALYSIS

TABLE 1: QUALITATIVE ANALYSIS

TABLE 2: QUANTATIVE ANALYSIS

Serial no	Name of the image	Size of image (pixel)	PSNR(using imadjust)	SSIM(using imadjust)	PSNR(using histeq)	SSIM(using histeq)
1	pout.tif	291x240	14.517224	0.584964	13.326646	0.562227
2	cameraman.tif	256x256	18.552456	0.918796	19.096977	0.810999
3	circuits.tif	280x272	16.019446	0.830617	12.674766	0.744992
4	tree.tif	258x350	11.629988	0.710909	9.477803	0.441193
5	rice.tif	256x256	19.259772	0.835082	16.282546	0.706566

TABLE 3: HISTOGRAM ANALYSIS

Serial no	Name of the image	Size of image (pixel)	Imhist	imhist(using imadjust)	imhist(using histeq)
1	pout.tif	291x240			
2	cameraman.tif	256x256			
3	circuits.tif	280x272			
4	tree.tif	258x350			
5	rice.tif	256x256			

From the above results, it can be seen that the values of PSNR and SSIM when used with image adjustment technique yield higher values and a much stretched histogram whereas the values of PSNR and SSIM when used with Histogram Equalization yield lower values and a less stretched Histogram. This is because of the fact that Image adjustment technique linearly scales the Histogram but Histogram equalization technique does not scales the Histogram linearly.

CONCLUSIONS:

Image Enhancement processes provide a wide scope of ways for enhancing an image to obtain a visually acceptable image. As there are a large number of digital devices that are used to take the images but the image gets corrupted because of some factors like color inversion and noise. So, there arises a need for a technique that can produce a required image. The principal aim is to improve the quality for human viewers to interpret the information required or to provide better input for automation. In this paper, we have tried to put light on some of the existing techniques such as Histogram Equalization and Image Adjustment along with their advantages and disadvantages along with their quantitative and qualitative analysis. Also, we have tried to find out the best process that can be applied for enhancing an image. From this analysis, we have concluded that Image adjustment technique is a better process for image enhancement as compared to the Histogram Equalization. The reason behind this conclusion is that the Image adjustment technique tends to make the image look more natural but the Histogram Equalization technique tends to make the image unnatural by introducing excessive brightness into the image. Also, the PSNR and SSIM values obtained above prove the explanations given. It can be visually observed that the image quality and the histogram of image adjustment are better than that of the histogram equalization. The future scope will be the development of better image enhancement techniques that can be applied in their respective fields.

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