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Evaluating the Performance of Enhancement Technique

Jagyanseni panda[1], Manaswinee Madhumita panda [2]

Asst.Prof, ECE Department, ITER, Bhubaneswar, India [1]

QA Engineer, Access InfoTech India Pvt Ltd, Chandigarh, India[2]

Abstract: Enhancement is the modification of image to better visualisation to the viewer. It is a technique to manipulate pixel value to produce an image with optimum contrast. The image used in medical, satellite and edge detection is not of a standard quality so to increase visual appearance and reduced noise enhancement of image is used. Although enhancement techniques differ according to application but they are broadly classified as two type: Spatial domain and Frequency domain. In spatial domain the image is modified i.e. pixel value of image & in frequency domain the frequency of image is modified. Here we will try to provide some image enhancement techniques in spatial as well as frequency domain and use some of the parameter to measure different technique shortcoming.

Keywords: Image enhancement, Histogram Equalization, Local Enhancement, Retinex, Homomorphic filtering.

I. INTRODUCTION

Image capture at different condition if is not good quality and is affected by noise so to increase the appearance of the image and to reduce the noise image enhancement technique is used. Here image contrast and brightness is change to give better visualisation. Image enhancement is done without the knowledge of image degradation. If the degradation is known then it is known as image restoration. Spatial domain techniques for image enhancement is Histogram equalization, Local Enhancement, Single scale Retinex .Frequency domain technique for image enhancement is Homomorphic filtering.

II. SPATIAL DOMAIN METHOD

Spatial domain techniques are based on direct manipulation of pixel value without any transformation. In spatial domain the pixel (x,y) is the result of some operation that is also applied to the neighbourhood pixel of (x, y) in image that is given by

$$g(x, y) = T[f(x, y)]$$

Where f is the original image. g is output image .T is the transform.

A. Histogram Equalization

Histogram equalization does not allow interactive image enhancement but only yields an image with uniform histogram. Before working with Histogram Equalization it is necessary to know two main concept of histogram equalization that are probability density function (PDF) and cumulative distribution function (CDF)[1],[2].

The probability Density Function is calculate using the following equation:

$$p(r_k) = \frac{\text{total pixels with intensity } r_k}{\text{total pixel in the image}}$$

Where $r_k$the intensity of the image and intensity is will range from $L - 1$ to 0.

And the cumulative density function is calculated as follows:

$$CDF(x) = \sum_{k=0}^{L-1} p(r_k)$$

The output pixels from histogram equalization operation are then equals to the CDF of the image and it is given by:

$$p(s_k) = \sum_{k=0}^{L-1} p(r_k)$$

To get the value of the pixel $p(s_k)$ need to be multiplied by $L - 1$ and then round it to the nearest integer.

Fig 1. Input image

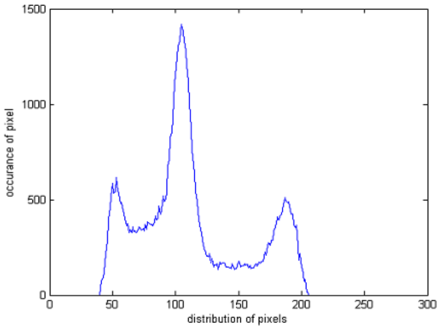

Fig 2. Histogram of input image

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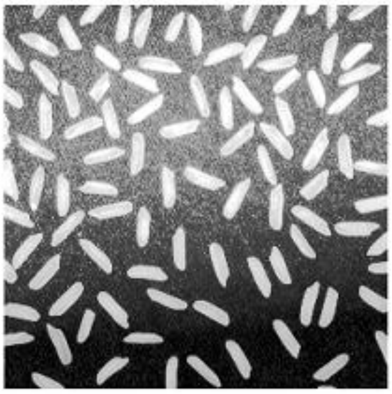

Fig 3. Enhance image after Histogram equalization

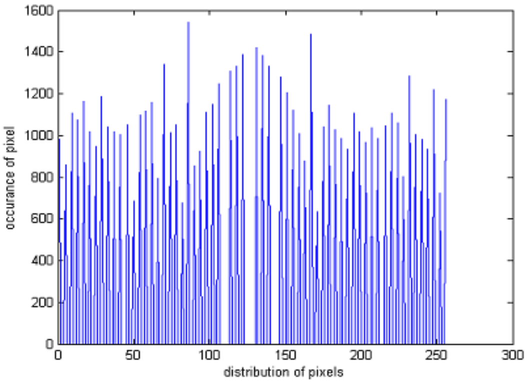

Fig 4. Enhance image histogram

Here we can see from Fig 2. the original image histogram pixel distribution ranges from 50 to 200 but after histogram equalization the distribution of pixel is from 0 to 250 as in Fig 4.

B. Local Enhancement

This method used to enhance the details over small area in the image. Here square or rectangular neighbourhood and move the centre of this area from pixel to pixel. At each location histogram specialization transformation is calculated [3]. Two parameters are calculated in local enhancement, where the local mean and local variance is calculated for each pixel in a predefined region and is given by

$$m = \sum_{k=0}^{L-1} r_k * p(r_k)$$

$$\mu = \sum_{k=0}^{L-1} (r_i - m)^2 * p(r_i)$$

Let (x, y) be co-ordinates of a pixel in a image and s_{xy} denote a neighbourhood centred at (x,y) the value $m_{s_{xy}}$ of the pixel in s_{xy} can be calculated as

$$m_{s_{xy}} = \sum_{(s,t)\in s_{xy}} r_{s,t} * p(r_{s,t})$$

Where $r_{s,t}$ is the grey level at coordinate(s,t) is the neighbourhood and $p(r_{s,t})$ is the neighbourhood normalizes histogram component. Similarly the grey level variance of pixels in the region $s_{x,y}$ is given by

$$\sigma^2_{s_{x,y}} = \sum_{(s,t)\in s_{xy}} \left(r_{s,t} - m_{s_{xy}}\right)^2 * p(r_{s,t})$$

The local mean is a measure of average gray level in neighbourhood$\boldsymbol{s_{xy}}$, and the variance is a measure of contrast in that neighbourhood. By taking the same input image as Fig 1. We get the enhance image using this method is given below

Fig 5.Output Local enhance image

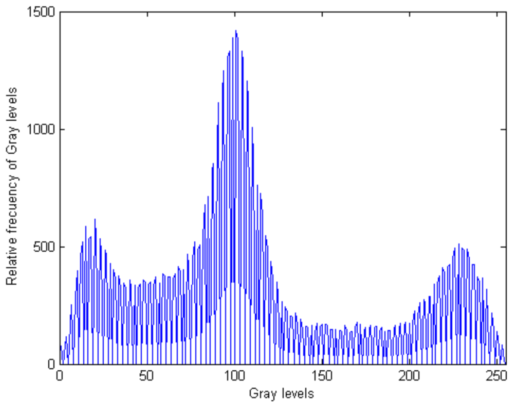

Fig 6. Histogram of enhance image

Here if we see the Fig. 2 the distribution of pixel is only from 50 to 200. But after the local enhancement the gray level distribution is cover the range from 0 to 250(Fig 6) .So it will gives a uniform distribution of grey scale value.

C. Single Scale Retinex

The Retinex is an image enhancement algorithm that performs a nonlinear spatial spectral transform that provides both dynamic range compression and color consistency [4].

The retinex is a number of class of centre surround function where each input value of the function is determine by the corresponding input value (centre) and its neighbourhood (surround).The input in retinex algorithm is an array of photoreceptor response for each location of the image. The lightness value for a single receptor class is calculated by

- Select a starting pixel ($\boldsymbol{x_1}$).
- Randomly select other pixel ($\boldsymbol{x_2}$).
- Calculate the difference of the sensor responses at the two positions.

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- The value obtained by previous step is added to the accumulator register for position of pixel (x_2) that is given by :

$$A(x_2) = A(x_2) + log(x_2) - log(x_1)$$

Where $A(x_2)$ accumulator register for pixel (x_2).
The above equation show how to calculate one path for a receptor class. Like this the path calculation is done with random selection of neighbour of pixel x_2. The general accumulation of position (x_i) on the path is updated by:

$$A(x_i) = A(x_i) + log(x_1)$$

In retinex class the retinex centre is defined as each pixel value and the surround is Gaussian function. This is represented by

$$R(x, y) = log[I(x, y)] - log[I(x, y) * F(x, y)]$$

Where I: is the input image and R: is the retinex output image and F is the Gaussian filter is defined by:

$$f(x, y) = kexp[\frac{-(x^2 + y^2)}{\sigma^2}]$$

Where σ the standard deviation of filter and k is is the normalization factor that keeps the area under the Gaussian curve. The result is given below:

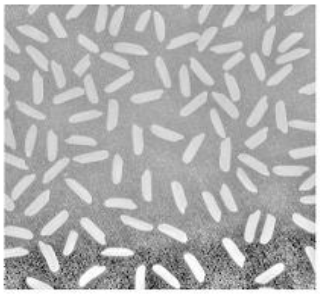

Fig 7. Enhance image

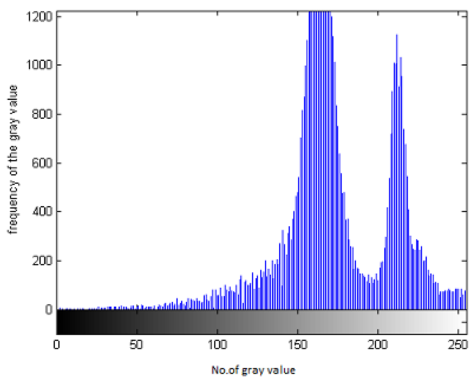

Fig 8.Histogram of enhance image

The fig.2 show the gray level only distributed from 50 to 200 gray level. But the enhance image histogram fig.8 gray level only distributed in particular portion .So it indicate single scale retinex output gives better contrast So this technique take the details out of shadows.

III.FREQUENCY DOMAIN

A. Homomorphic filtering

Here to improve the appearance of an image it is required to compress the brightness range and contrast enhancement so it is required to separate illumination and reflectance[5],[7].

In homomorphic filtering the following steps are used:

$$f(x, y) = I(x, y)r(x, y)$$

Here image f is represented in terms of illumination I and reflectance r .First take the natural log and then take the Fourier transform:

$$c(x, y) = ln\{f(x, y)\} = ln\{I(x, y)\} + ln\{r(x, y)\}$$

Then

$$F\{c(x, y)\} = F\{ln\, I(x, y)\} + f\{ln\, r(x, y)\}$$

Or it can be represented as

$$C(u, v) = I(u, v) + R(u, v)$$

C (u, v) by means of filter function H (u, v) then

$$S(u, v) = H(u, v)C(u, v)$$
$$= H(u, v)I(u, v) + H(u, v)R(u, v)$$

By taking inverse fourier transform of natural log we get

$$s(x, y) = i_0(x, y)r_0(x, y)$$

Where $i_0(x, y)$ is illumination and $r_0(x, y)$ is reflectance component of the output image. The resulting image obtain by homomorphic filtering by taking same input image as given in Fig1.

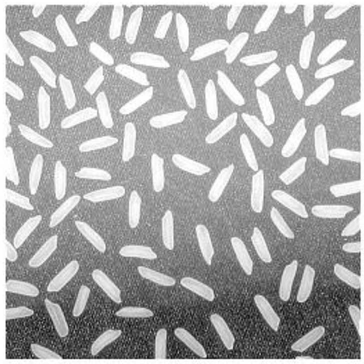

Fig 9. Enhance image after homomorphic filtering

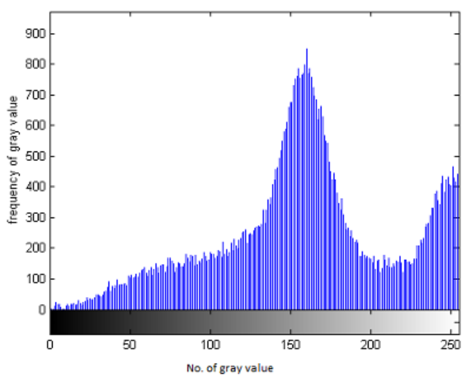

Fig 10. Histogram of enhance image

The histogram of enhance image show that it compress the dynamic range of low frequency component and enhances the contrast that high frequency component of an image.

IV. PERFORMANCE PARAMETER

The performance of different method depends on observation of viewer. But there is certain parameter given below:

A: Peak Signal to noise ratio (PSNR)

PSNR is standard of reconstructed image quality and is an important measurement feature [6]. It is in db. Let f is the

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reference image and t is the test image both of same size (M*N) the PSNR between f and t is given by:

$$PSNR(f,t) = log\ log_{10} \frac{(L-1)^2}{MSE(f,t)}$$

Where L is gray level & MSE (mean square error) is calculated as:

$$\mathrm{MSE(f,t)} = \frac{1}{\mathrm{MN}} \sum_{\mathrm{i=1}}^{\mathrm{M}} \sum_{\mathrm{j=1}}^{\mathrm{N}} (\mathrm{f_{ij}} - \mathrm{t_{ij}})^2$$

Note the greater the PSNR the better output image quality.

B: Mean Squared Error (MSE)

It deals with the values obtained by calculating difference between estimated value and optimumvalues ofestimated quantity. MSE quantifies the average of squares of the ‘‘ errors’’. The higher value of MSE the better.

C: Pearson Correlation Co-efficient (PCC)

The Pearson product-moment correlation co-efficient is measure the correlation i.e. the strength of linear dependence between two variable x and y and a value between +1 and -1 inclusive

$$\mathrm{pcc} = \frac{(\mathrm{n}\sum \mathrm{xy}) - (\sum \mathrm{x})(\sum \mathrm{y})}{\sqrt{[\mathrm{n}\sum \mathrm{x}^2 - (\sum \mathrm{x})^2] - [\mathrm{n}\sum \mathrm{y}^2 - (\sum \mathrm{y})^2]}}$$

V. RESULT

The PSNR, MSE, PCC are used to get the performance of different enhancement method.

TABLE I

parameter	Psnr(dB)	Mse	Pcc
Histogram Equalization	16.31	0.0766	6.324
Local enhancement	20	0.0011	6.55
Single scale Retinex	11	0.075	5.39
Homomorphi c filtering	13	0.0591	6.31

VI. CONCLUSION

In the above table the Power to signal noise ratio is better in local enhancement method and in this the PCC value is greater comparing to other algorithm. So local enhancement is better method for enhancing the image.

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BIOGRAPHY

Jagyanseni panda received the B. Tech degree in Electronics & Telecomm, Engineering from Orissa Engineering College and M. Tech. Degree from Silicon Institute of Technology in 2009 and 2011, respectively. Now I am working as Asst. prof. at SOA University, Bhubaneswar. And my area of research is Image processing and pattern recognition.

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