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Image Optimization using Wavelet based Approach and Quality Assessment of Compressed Image

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Abstract
In this section proposed an algorithm based on stochastic resonance to enhance the low contrast image. This algorithm is based on thresholding, mean, minimum, maximum and standard deviation only. In this noise is added repeatedly, and also utilize the well known histogram technique of image processing. Easy to implement is an advantage of this proposed algorithm. To verify the utility of this algorithm, this is applied to low contrast standard Lena image and other real life images.

Introduction

Some features are hardly detectable from very low contrast image by human eyes. Therefore, it is needed to enhance the contrast before display. This can be done by many methods like adaptive histogram equalization, unsharp masking, constant variance enhancement, homomorphic filtering, high-pass, low-pass filtering etc. [1]. It has been observed that each method is restricted to some kind of images and for some particular enhancement application. For example, the method given in [2] is used for mainstream digital cameras for capturing high dynamic scenes. Methods described in [3] are used for enhancement of medical images like mammography. The strengths and weaknesses of these methods were also pointed out. It has also been mentioned that the Log transforms [4] increases the contrast very well at low intensity range but compresses the contrast at high intensity range. In histogram equalization [5], brightness of an image can be changed, which is mainly due to the attening property of the histogram equalization. Wavelet based algorithms [6] offer the capability of modifying/enhancing image components adaptively based on their spatial-frequency properties. The dynamic range and local contrast in wavelet domain is not adjusted properly. The Retinex method is efficient for dynamic range compression, but does not provide good tonal rendition [7]. The Multiscale Retinex (MSR) combines several single stage Retinex outputs to produce a single output image which has good dynamic range compression, color constancy [8] and good tonal rendition [9]. In addition to these existing techniques for enhancement, SR is also applied for contrast enhancement of very low contrast images [10].

In recent time the surveillance systems are in demand for security and safety. The problems of remote surveillance have received growing attention, especially in the context of public infrastructure and monitoring. For surveillance application, in the night time at the line of control, stochastic resonance algorithm is useful to enhance very low contrast images. Non-dynamic stochastic resonance based contrast enhancement has two advantages over the other enhancement techniques. Firstly, it is able to enhance very low contrast images. This is because, in this approach Gaussian random noise is added to all pixels of very low contrast image and then thresholded the noisy image.

Since the added noise is random, so, the thresholded image for individual random noise is different. Now, multiple noisy thresholded images are averaged, which is basically non-linear averaging. The error generated due to non-linearity (threshold) (in one noisy image) is minimized by averaging of different thresholded noisy images. So, it enhances specially those regions where pixels information are very-very less. Secondly, there is no blocking or spot kind of artifacts introduced in SR enhanced image. This is due to averaging operation or linearity operation of multiple thresholded images.

In this chapter a novel enhancement techniques are investigated. Both these techniques are based on conventional SR phenomenon. Gaussian noise is used in stochastic resonance phenomenon for image enhancement. The density of low intensity noise samples in Gaussian noise is greater than density of high intensity noise samples. Due to this the higher intensity values in the low contrast image becomes one and the lower intensity values becomes zero after addition of Gaussian noise and thresholding. This gives better contrast in the low level image so the dynamic range of the image increases.

Secondly, averaging number of noisy frames reduces noise present in the image and so quality of enhanced image increases.

To extract information from low contrast image, a new SR based enhancement algorithm is proposed. The new method is based on goodness of the noisy low contrast image which is a statistical approach. This approach focuses on finding the overall goodness of noisy image which describes the optimal noise standard deviation for enhancement of very low contrast images.

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SR Based Image Enhancement Technique

This section discusses the first new proposed technique for enhancement of images. From transformation technique, it is well known that any random signal can be represented as sum of sinusoidal components of different frequency, amplitude and phase. Same is true for images also. When a gaussian noise of standard deviation σ is added to the image and the noise added image is thresholded the SNR of output signal is given by equation which is of the form

$$SNR = \frac{P_s(f)}{P_n(f)} = \frac{2f_0\Delta_0^2}{\sqrt{3}\sigma^4}\sum_{i=1}^{N}[B_i^2]exp\left(-\frac{\Delta_0^2}{2\sigma^2}\right).$$

Where *Bi* is the amplitude of i^{th} sinusoidal component of input signal.

Simulation Steps

The proposed new adaptive stochastic resonance based image enhancement techniques are given below.

- **Step-1** Very low contrast image img(*x; y*) is taken as an input image. Set $\sigma = \frac{M}{2}$ where M is average image intensity value.
- **Step-2** First plots the histogram of low contrast input image. Decide its threshold using histogram concept. Let it be T_1
- **Step-3** Using this threshold concept the given image is divided into two parts. Let us assume it may be I_1 and I_2.
- **Step-4** Take mean of the values of I_1 and I_2. Imin and Imax are the value of mean of each part of input image.
- **Step-5** Now calculates another threshold for calculating range of standard deviation. This can be taken as square root of variance of image. Let this threshold be T_2
- **Step-6** Now Calculate the range of Standard deviation using value Imax and Imin as given below.

Simulation parameter

Smin = T_2

Smax = sqrt((T_2+Imax)*(Imin+Imax+2* T_1))/2

Here Imax and Imin representing the highest and lowest luminance of image.

1. Decide the no. of Frames, it is randomly chosen. In this thesis it is taken as 100.
2. Starting from Smin to Smax obtain one image corresponding to every increment. The increment is decide by the computation availability and quality of image enhancement in each step
3. To obtain output images. Optimized image is decided based on varies parameter
   For every frame
   img(x,y)=img(x,y)+noise(I,mean)
   I belongs [Smin Smax]
   For Calculating the Variance of this Noise image .
   Take square root. Let it be Tn
   Now make comparison of image intensity with this Tn and add 255 if greater else add zero.
   Divide this sum up array with No. of frames.

Results:

Enhanced and informative image is necessary requirement of many real life applications. For the verification of efficiency of this proposed algorithm, thesis start with standard Lena image. First take low contrast Lena image of size 512x512 and applied proposed mention algorithm. The output image is well enhanced in visualization. Here in SR noise behavior is opposite to general believes about it. Traditionally believe that noise is destructive and presence of this can make system worse. Figures show the algorithm performance on Lena image. Also plot the PSNR value with number of frame of noise. It is found that increase with increasing the number of noise frame, optimal value of PSNR reach. After optimal value PSNR start decreasing with increasing the number of frame and constant with it after a certain values. The plot between PSNR with number of frames is given below. PSNR valuesis calculated using the following formula.

$$\mathrm{PSNR} = 10\log_{10}\frac{255^2}{\mathrm{MSE}}$$

The mean square error (MSE) is is calculated using this equation.

$$\mathrm{MSE} = \frac{1}{M \times N}\sum_{i=1}^{M}\sum_{j=1}^{N}(y(i,j) - x(i,j))^2,$$

Here M and N are the number of rows and columns of input low contrast image.

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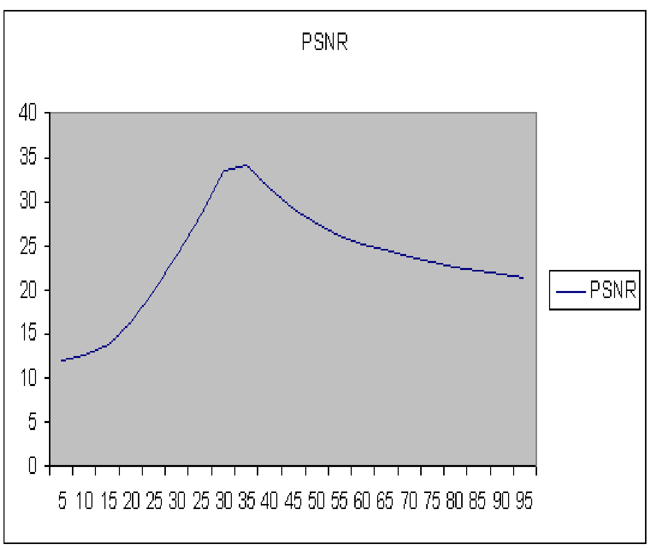
Test Low Contrast Lena image

Optimal Lena image

S_{min} Lena image

S_{max} Lena image



The value of PSNR remains same for certain range of value. This value is dependent on property of image.

After get enhanced image with proposed algorithm, applied this algorithm to the other images of different size. Take low contrast cartoon image of size 256x256 and applied proposed algorithm. The enhanced image is given in figure.

Low contrast cartoon image

Enhanced cartoon image

Enhancement of cartoon image along Lena image clearly indicate that this algorithm can be apply of useful images like thumb impression, biomedical images and other low contrast images. It can also be applied for colour images also.

Conclusion

Stochastic Resonance based algorithm enhanced the low contrast image by using thresholding. Easy to implement is an advantage of this algorithm. Here noise plays a constructive role in place of degrade the system perforations. Image is getting Enhanced according to the property of original image hence in the obtained results no spot are seen which make this method more acceptable.

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