Contrast Enhancement of grey level and color image using DWT and SVD

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Abstract - *With the fast advance of technologies and the prevalence of imaging devices, billions of digital images are being created every day. Due to undesirable light source, unfavorable weather or failure of the imaging device itself, the contrast and tone of the captured image may not always be satisfactory. Therefore, image enhancement is often required for both the aesthetic and pragmatic purposes. Contrast enhancement technique is capable to clean up the unwanted noises and enhance the images brightness and contrast. The proposed algorithm enhance brightness and contrast simultaneously without changing color. This is applicable to any format of image and of any size.*

***Key Words*: GHE, DWT, IDWT,SVD**

1. INTRODUCTION

Contrast enhancement is frequently referred to as one of the most important issues in image processing[8]. General Histogram Equalization is one of the common methods used for improving contrast in digital images[3]. The conventional histogram equalization methods usually result in excessive contrast enhancement, which causes the unnatural look and visual artifacts of the processed image[4]. The idea behind image enhancement is to bring out the detail that is obscured and also to highlight certain features of interest in an image[7]. Visual system is more sensitive to contrast. Contrast of an image is determined by its dynamic range, which is defined as the ratio between brightest and the darkest pixel intensities[1]. There exist many methods to enhance contrast[2]. But the proposed technique works for the quality of an image with respect to brightness as well as contrast simultaneously[5].

1.1 GHE

Histogram equalization is used to enhance the contrast of the image, it spreads the intensity values over full range. Histogram equalization technique can't be used for images suffering from non-uniform illumination in their backgrounds as this process only adds extra pixels to the light regions of the image and removes extra pixels from dark regions of the image resulting in a high dynamic range in the output image. The goal of histogram equalization is to spread out the contrast of a given image evenly throughout the entire available dynamic range. A key advantage of this technique is that it is fairly straightforward and effective. The calculation is not computationally intensive. It is powerful in highlighting the borders and edges between different objects, but may reduce the local details within these objects, especially smooth and small ones.

A good histogram is that which covers all the possible values in the gray scale used. This type of histogram suggests that the image has good contrast and that details in the image may be observed more easily.

1.2 DWT

DWT provides multi resolution representation of image and can efficiently implemented using digital filters. Image itself is considered as two dimensional signal. When image is passed through series of low pass and high pass filters, DWT decomposes the image into sub bands of different resolutions. An image is decomposed into four sub-bands denoted LL, LH, HL, and HH at level 1 in the DWT domain, where LH, HL and HH represent the detail wavelet coefficients and LL stands for the coarse coefficients. High frequency sub-band contains high frequency component, it contains edge information so can be used for increasing resolution. Where LL sub-band is nothing but low resolution of original image which contains illumination information so can be used for enhancing contrast.

1.3 SVD

Singular Value Decomposition method can transform matrix A into USV^T product which allows us to refactoring of a digital image into three matrices. The using of singular values of such refactoring allows us to represent the image with a smaller set of values, which can preserve useful features of the original image, but use less storage space in the memory. The singular value matrix represents intensity information of a given image and any image into three matrices. The using of change on singular values change intensity of input image, hence other information in the image will not be changed. Singular Value decomposes an image into three matrices. Singular value matrix 'S' obtained by SVD contains the illumination information. SVD of an image, which can be interpreted as matrix, is written as follows:

$$A=USV^T \qquad (1.1)$$

Where, U and V are orthogonal square matrices known as hanger and aligner, respectively. S Matrix contains the sorted singular values on its main diagonal. The idea of using SVD for equalizing image comes from the fact that S contains intensity information of a given image.

2. PROPOSED ALGORITHM

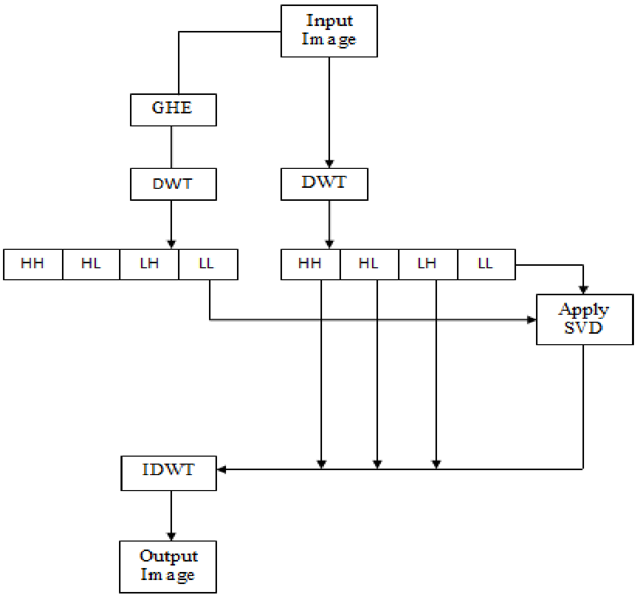

Fig – 1: Detailed steps of proposed algorithm

Step 1: Applying GHE

The input image I is first processed by using GHE to generate Î.

Step 2: Applying DWT

Both of these images I and Î are transformed by DWT into four sub-bands. Using LL sub-bands obtained after applying DWT, correction coefficient is to be obtained by the following equation.

$$Correctioncoefficient = \frac{\max(\sum LL_{\hat{I}})}{\max(\sum LL_{I})} \quad (2.1)$$

Where, ΣLL Î is the LL singular value matrix of output of GHE and ΣLL I is the LL singular value matrix of input image.

Step 3: Finding new LL

New LL of an image is composed by multiplying correction factor with ΣLL I

Now, the new LL sub-band that is obtained and higher sub-bands of DWT are then recombined by applying Inverse Discrete Wavelet transform to generate resultant equalized image Î.

And thus obtained image is enhanced for both contrast as well as brightness.

Performance is analyzed through different quality measures.

2.1 Mean

Mean is the average of pixel values. Mean is required to calculate standard deviation which is the quality measure for contrast enhancement. And it is given as

$$M = \frac{Sum\ of\ all\ pixels\ in\ an\ image}{Total\ number\ of\ pixels\ in\ an\ image} \quad (2.2)$$

2.2 Standard Deviation

Standard Deviation is calculated using mean value. Standard Deviation value gives the deviation of pixel from its mean value i.e. deviation value tells us spread between the pixels. Spreading between the pixels is used to check its contrast enhancement, as if pixels are distributed along grey levels equally then

that image is said to be highly contrast image. It is given as:

$$S = \sqrt{\frac{\sum (x_i - M)^2}{N-1}} \quad (2.3)$$

2.3 PSNR

Peak signal to noise ratio, often abbreviated PSNR, is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale.

PSNR is most easily defined via the mean squared error (*MSE*). Given a noise-free $m \times n$ monochrome image I and its noisy approximation K, MSE is defined as:

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2 \quad (2.4)$$

The PSNR (in dB) is defined as:

$$PSNR = 10 * \log_{10} \left(\frac{MAX_I^2}{MSE} \right) \quad (2.5)$$

3. Experimental Results

Fig 3.1.1: Sun image before DWT-SVD algorithm

Fig 3.1.2: Sun image after DWT-SVD algorithm

Fig 3.2.1: Grass image before DWT-SVD algorithm

Fig 3.2.2: Grass image after DWT-SVD algorithm

Table 3.1: Mean and PSNR for the images

Image	Mean of the input image	Mean of the output image	PSNR for the proposed technique (dB)
Sun	103.9569	139.5868	24.0799
Fly	108.0994	139.8722	24.0654
Grass	32.0569	84.9608	27.3497

Table 3.2: Standard Deviation for the images

Image	Standard Deviation of the input image	Standard Deviation of the output image
Sun	84.8888	114.0965
Fly	121.3856	157.5604
Grass	21.9057	47.2239

4. CONCLUSION AND FUTURE SCOPE

In this paper, a new image contrast enhancement technique based on DWT and SVD has been proposed. This technique decomposed the input image into the DWT sub bands, and after updating the singular value matrix of the LL sub band, it reconstructed the image by using IDWT. The proposed technique was compared with GHE techniques for visual and quantitative performance evaluation. The quantitative results supports the visual results that the quality and information content of the equalized images are better preserved through the proposed DWT and SVD technique over GHE techniques.

DWT and SVD technique enhance contrast as well as brightness and also enhance color images. This will be applicable to all types of images and any size. In future, we will design the algorithms with simple functions and get the enhanced output quickly.

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