Image Compression Using Wavelet Transform

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***Abstract*— The swift development in digital technology has increased the use of images in practically all the applications. The extensive use of these images have raised the need of image compression, so as to save memory and transmission bandwidth of the medium. This paper focuses on the grayscale image compression using wavelet transform. This method provides lossy image compression of images. Authors also examine the performance of the compression by various performance indicators like Compression Ratio, Mean Square Error and Peak Signal to Noise Ratio.**

Keywords*— Image, Wavelet Transform, Compression, PSNR, MSE.

I. Introduction

A digital image is a rectangular array of pixels sometimes called a bitmap.It is represented by an array of N rows and M columns and usually N=M. Typical values of N and M are 128, 256, 512 and 1024 etc.A gray scale image that is 256 x 256 pixels has 65,536 elements. Image Compression is a procedureused to reduce the amount of data used to represent a digital image. The reduction in the data reduces the number of bits required to store or transmit the image over digital media.

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Image compression is also of two types: First, Lossless, in which the reconstructed image is exact replica of the original image.If the reconstructed image after the compression is exactly identical to the original image then the compression is known as lossless compression. Second, Lossy, where the reconstructed image is not an exact replica of the original image.If the reconstructed image after compression is not exactly same as the original image then the compression is known as lossy compression. In lossy compression, there is always some loss in the data.The extent of compression is more in lossy compression techniques compared to lossless compression techniques, but the superiority of reconstructed image is good in lossless compression.

II. Performance Indicators

A. Compression Ratio

Compression ratio is the ratio of numbers of bits required to represent original image to the number of bits required to represent compressed image.

$$\textit{Compression Ratio} = \frac{\textit{Uncompressed Size}}{\textit{Compressed Size}}$$

B. Mean Square Error (MSE)

Mean square error is the cumulative squared error between the compressed image and the original image.

$$MSE = \frac{1}{MN}\sum_{y=1}^{M}\sum_{x=1}^{N}[I(x,y) - I'(x,y)]^2$$

C. Peak Signal to Noise Ratio (PSNR)

Peak Signal to Noise Ratio is the ratio if maximum power of the signal and the power of unnecessary distorting noise.

$$PSNR = 20 \times log_{10}\left[\frac{255}{\sqrt{MSE}}\right]$$

III. Wavelet Transform

Wavelets are functions defined over a finite interval and having an average value of zero. The main purpose of wavelet transform is to represent any arbitrary function as a superposition of a set of such wavelets or basis functions. The discrete wavelet transform of a finite length signal x(n) having N components is expressed by an NxN matrix.

In many applications wavelet-based schemes (also referred as sub band coding) outperform other coding schemes like one based on DCT. Wavelet-based coding is more robust under transmission and decoding errors, and also facilitates progressive transmission of images.

A. Threshold Values

For the compression of image, firstly the DWT is applied in the image using threshold value. Threshold values neglects the certain wavelet coefficients, for doing this one has to decide the value of threshold. Value of threshold affects the quality of compressed image.

Thresholding can be of two types:

1) *Hard Threshold:*

If *x* is the set of wavelet coefficients, then threshold value *t* is given by,

$$T(t;x) = \begin{cases} 0, if\ |x| < t \\ x, otherwise \end{cases}$$

i.e. all the values of *x* which are less than threshold *t* are equated to zero.

2) *Soft Threshold:*

In this case, all the coefficients x lesser than threshold t are mapped to zero. Then t subtracted from all x,t. This condition is depicted by following equation:

$$T(t;x) = \begin{cases} 0 & if\ x < t \\ sign(x)(|x| - t) & otherwise \end{cases}$$

Usually, soft threshold gives a better signal to noise ratio (PSNR) as compared to hard threshold.

IV. Results

Simulations of various images have been performed using MATLAB.

A. Image 1

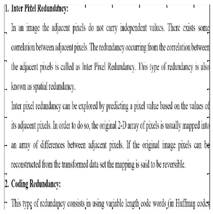
1. Inter Pixel Redundancy:
In an image the adjacent pixels do not carry independent values. There exists some correlation between adjacent pixels. The redundancy occurring from the correlation between the adjacent pixels is called as Inter Pixel Redundancy. This type of redundancy is also known as spatial redundancy.
Inter pixel redundancy can be exploited by predicting a pixel value based on the values of its adjacent pixels. In order to do so, the original 2-D array of pixels is usually mapped into an array of differences between adjacent pixels. If the original image pixels can be reconstructed from the transformed data set the mapping is said to be reversible.
2. Coding Redundancy:
This type of redundancy consists in using variable length code words (in Huffman code

Fig. 1. Original Image 1

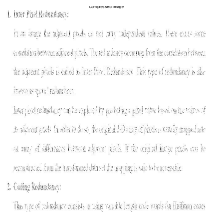

Fig. 2. Reconstructed Image 1

B. Image 2

Fig. 3. Original Image 2

Fig. 4. Reconstructed Image 2

C. Image 3

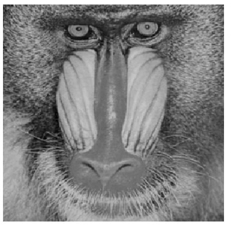

Fig. 5. Original Image 3

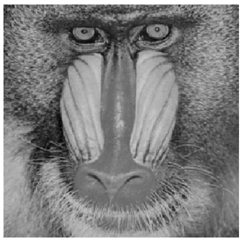

Fig. 6. Reconstructed Image 3

D. Image 4

Fig. 7. Original Image 4

Fig. 8. Reconstructed Image 4

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TABLE I. Compression Ratios of Different Images

Image	Type of Image	Compression Ratio
Image 1	JPEG	67.6743
Image 2	PNG	84.2773
Image 3	JPEG	10.7651
Image 4	PNG	60.6735

V. Conclusion

The wavelet transform can be used as a lossy image compression technique. This technique provides good compression to grayscale images. Wavelet transform is much suitable for low bit rate images. Wavelet transform can provide compression ratio of 60-80.

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