Intensity Reduction Method Using Wavelet for Compressing Grey Scale Images

KEYWORDS: Image, Compression, Haar Wavelet, Lossy.

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ABSTRACT *Image compression techniques are used to reduce the cost associated with storage and transmission. They are classified into two types: (i) Lossy compression (ii) Lossless compression. In this paper, we have proposed a novel approach, Intensity Reduction Method (IRM) to compress the images using Haar Wavelet. The feature of inter-pixel redundancy is exploited to achieve good compression ratio in this approach. Standard images like Lena, Jet, Peppers, Barbara and Boats of size 256 x 256 pixels are tested with the proposed method which yields a better PSNR (quality of the reconstructed image) than a few existing compression techniques. The computational complexity of the proposed method is also less when compared to that of existing techniques.*

1. INTRODUCTION
Image compression is used to reduce the amount of storage required to represent a digital image. Compression techniques also reduce the time taken to transmit the compressed images. Generally images have redundant data and this feature can be exploited to compress the data required to represent the image.

1.1 IMAGE COMPRESSION TECHNIQUES
The image compression [1] techniques are broadly classified into two categories depending whether or not an exact replica of the original image could be reconstructed using the compressed image namely 1. Lossless and 2. Lossy techniques. In lossless techniques, the reconstructed image, after compression, is numerically identical to the original image. Some of the lossless compression techniques: 1. Run Length Encoding [2], 2. Huffman Encoding, 3. LZW Coding, and 4. Area Coding [3]. In lossy image compression, the decompressed image is not identical to the original image, but an approximation of the original image. Some of the lossy compression techniques: 1.Transformation Encoding, 2.Vector Quantization, 3. Fractal Coding, 4.Block truncation Coding, 5.Sub-band Coding [4].

Wavelets provide a mathematical way of encoding information in such a way that it is layered according to level of detail [5]. Wavelets are applied in Signal Processing, Data Compression, Smoothing and Image Denoising, Fingerprint Verification, DNA Analysis, Speech Recognition, Computer Graphics and Multifractal Analysis.

1.2 WAVELET TRANSFORM
A Wavelet representation provides access to a set of data at various levels of detail. Wavelet transform does not reduce the amount of data present in the image. The objective of image compression technique is to reduce redundancy of the image data in order to be able to store or transmit data in an efficient form. This results in the reduction of file size and allows more images to be stored in a given amount of disk or memory space. Transform coding is a widely used method of compressing image information. In a transform based compression system two-dimensional (2-D) images are transformed from the spatial domain to the frequency domain. An effective transform will concentrate useful information into a few of the low-frequency transform coefficients [6].

1.3 DISCRETE WAVELET TRANSFORM
Discrete wavelet transform based on image compression adopts the fast algorithm for two dimensions. The original image decomposes into four sub parts after passing the image into high pass filter and low pass filter. The four subbands are LL, HL, LH and HH respectively. LL is a low frequency sub-band of the approximate image. HL is a high frequency sub-band of the horizontal details of the image. LH is a high frequency sub-band of the vertical details of the image. HH is a high frequency sub-band of the diagonal details of the image [7].

1.4 HAAR WAVELET
Haar wavelet is the simplest wavelet. Haar transform or Haar Wavelet Transform (HWT) has been used as an earliest example for orthonormal wavelet transform with compact support. The Haar wavelet transform is the first known wavelet and was proposed in 1909 by Alfred Haar [8]. This is also called mother wavelet. The Haar Wavelets are orthogonal, and their forward and inverse transforms require only additions and subtractions. It makes that it is easy to implement them on the computer. The Haar Transform (HT) is one of the simplest and basic transformations from the space domain to a local frequency domain [9].

The advantages of Haar Wavelet transform:
1. Best performance in terms of computation time
2. Computation speed is high
3. Simplicity
4. HWT is efficient compression method.

1.5 EXISTING METHOD
In LCIC method, they combined quad tree, bit plane omission, bit plane coding and interpolative bit plane coding [10]. The quad tree segmentation technique is employed in another scheme to exploit the variable-block-sized segmentation and the bit plane omission technique is employed [11]. In another existing method, they combine all the three BTC methods [12].

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2. PROPOSED METHOD

In the proposed method, Haar wavelet is applied to the original image. The result of the wavelet have four subbands namely LL, LH, HL, HH. Select the LL (Low frequency subband) band to which Intensity Reduction Method (IRM) is applied. The image is divided into small blocks of size 4 x 4 pixels in the Encoding phase. It is a variable bit rate coding method where each compressed block requires different number of bits for storing them. For each block, the minimum intensity value *MinInt* is identified and this minimum value is subtracted from every pixel value using the equation (1).

$$X'_i = X_i - MinInt \qquad (1)$$

Where i ranges from 1 to 16 and X_i is the individual pixel value. The input image block, after encoding, is then transformed into a set of {*MinInt, {d1, d2,…., dn*}} where *d1, d2, … dn* are the difference between the *MinInt* and the respective pixel values. In the Decoding phase, the minimum value is added to all the difference values d_i to get back the original values which form the LL band. The other bands LH, HL and HH are generated as zero matrices. Inverse *dwt* is

Algorithm

Step1: Apply the Haar wavelet to the image.
Step2: Select the Low frequency subband (LL).
Step3: Split the image into blocks of size 4 x 4 pixels.
Step4: Find the minimum of all pixel values for each block.
Step5: Transform each pixel value using the equation (1).
Step6: Store or transmit the transformed blocks along with their minimum pixel values (*MinInt*).

Computation of the Compression Rate

After applying wavelet, an image if size 256 x 256 pixels are reduced to a LL band of size 128 * 128 values. This band becomes the input image for the proposed method. In the next level, further compression is achieved as follows:

For a sample block of following values

156	156	156	157
156	156	156	157
156	156	156	157
156	156	156	157

The minimum value *MinInt* is identified as 156. This value is subtracted from each pixel value and the transformed block will be

Transformed Block

0	0	0	1
0	0	0	1
0	0	0	1
0	0	0	1

Now the bits required to store the compressed block is computed using the equation (2).

$$\text{Log2}(156) + 16*\text{Log2}(1) = 23 \qquad (2)$$

Bits to store the minimum value (Log2 (IntMin)) → 7

Maximum no. of Bits to store each pixel value Log2 (1) → 1

Total No. of bits required to store the compressed block → 7 + 16*1 = 23.

The above computation is repeated for all the input image blocks to compute the bitrate for the entire image.

The difference between the original image and reconstructed image is called Mean Square Error (MSE) and is calculated using the equation (3). The quality of the reconstructed image called the Peak Signal to Noise Ratio (PSNR) is calculated using the equation (4) and is the inverse of MSE.

$$\text{MSE} = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - I'(i,j)]^2 \qquad (3)$$

where, *I* is the original image and I' is the reconstructed image and *m* and *n* are the number of rows and columns of pixels.

$$\text{PSNR} = 10\log_{10}[255\text{^}2/MSE] \qquad (4)$$

3. RESULT AND DISCUSSION

Standard images such as Peppers, Jet and Barbara are used for the study and are given in Fig. 1.

The work is implemented using Matlab 7.11.0 on Windows Operating System (Version 7). The hardware used is the Intel Core i3, 32 bit processor with 2 GB RAM.

Fig 1: Input images taken for the study

The original and the reconstructed images are given in Fig. – 2 for visual compression.

Fig 2: Reconstructed Images

Table 1: PSNR OBTAINED WITH THE EXISTING AND PROPOSED METHOD

IMAGE	EXISTING METHOD						PROPOSED METHOD	
	AMBTC		Yu-Chen-Hu		LCIC-AMBTC		IRM	
	Bpp	PSNR	Bpp	PSNR	Bpp	PSNR	Bpp	PSNR
Lena	2.00	35.25	0.46	29.06	0.47	30.67	2.07	35.78

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Jet	2.00	31.42	0.46	28.80	0.48	30.79	2.35	35.00
Peppers	2.00	33.44	0.44	28.80	0.44	30.64	2.06	35.87
Barbara	2.00	29.87	0.75	24.50	0.72	26.36	2.11	35.21
Boats	2.00	31.55	0.60	27.65	0.59	29.54	2.09	33.72
Average PSNR	32.31		27.76		29.60		35.12	

From Table1, for all images the PSNR obtained with the proposed method are better. For Barbara image, the PSNR obtained is 35.21, which is better when compared to that of the values obtained with AMBTC, Yu-Chen-Hu and LCIC-AMBTC whose PSNR values are 29.87, 24.50 and 26.36 respectively. In all the cases, the proposed work yields better results in terms of PSNR. On an average, a PSNR value of 35.12 is obtained with the proposed method which is a significant improvement. This method can also be applied for color image and video compression and most suitable for hand-held devices.

The significant raise in PSNR values obtained with the proposed method (IRM) and the comparison against the existing techniques is given in Fig.-3.

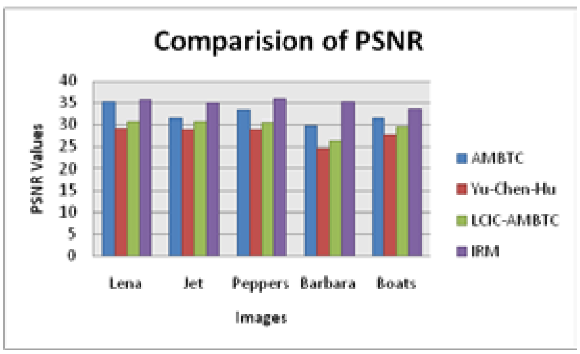

Fig.-3: Comparison of PSNR values with respect to existing and proposed methods.

4. CONCLUSION

In this paper, a novel approach called Intensity Reduction Method (IRM) for improving the PSNR is introduced. Standard images of size 256 x 256 pixels were tested with the proposed method and the compression has been improved by a significant level without degrading the quality of the reconstructed images. The computation involved in compressing the images with the proposed method is so simple. Implementation in hardware is easy due to its simplicity. The proposed method can both be used for medical and ordinary images as it is a lossy compression technique. The method can also be applied for color images and video.

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