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A Proposed Method for Image Compression Using Discrete Wavelet Transform and Absolute Moment Block Truncation Coding

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Abstract

In this paper, a hybrid image compression method has been presented. This method consists of two stages: the first involves the DWT (Discrete Wavelet Transform) which is used to convert image from spatial domain to frequency domain and the second stage involve the AMBTC (Absolute Moment Block Truncation Coding) that used to compress some of image data. The experimental results show that the proposed method has a very good performance, such it gives higher PSNR values with suitable value of compression ratio compared with the conventional method of AMBTC.

Key words: Image Compression, Discrete Wavelet Transform, AMBTC, PSNR.

1. Introduction

Images are one of the most important media that used nowadays, and decreasing the bandwidth and space to transport them is a benefit, image compression aims to reduce the number of bits in transmission and that leads to increase the volume of data transferred in space of time, image compression has became important to most of computer networks.

The human visual system (HVS) is not sensitive to changes in higher frequencies, this part of information can be employed by image compression techniques, converting an image from spatial domain to frequency domain gives the ability to control the values of the higher frequencies of an image. The Discrete Wavelet Transform (DWT) is one of the most significant transformations that used to convert data from spatial domain to frequency domain [1].

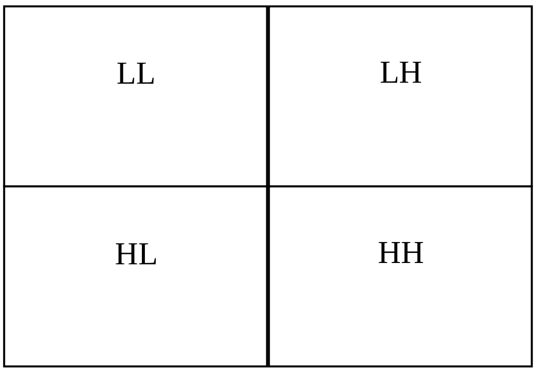
The AMBTC is a lossy image compression method that was presented by Lema and Mitchell [2]; it was an improvement of the original method Block Truncation Coding (BTC). The AMBTC plays an important role in image compression, it preserves the higher mean and the lower mean of the sub image blocks before and after compression.

This paper organized as follows: Section 2 gives a brief introduction to DWT, Section 3 talks briefly about AMBTC method. Section 4 discusses the proposed method in details. Experimental results are given in Section 5 and finally the conclusions are given in Section 6.

2. Discrete Wavelet Transform

The DWT is one of the fundamental processes in the JPEG 2000 image compression method [3]; it is a transform that can convert a block of data from spatial domain to frequency domain. DWT returns information about localized frequencies in data set.

The 2D-DWT (Two Dimension-Discrete Wavelet Transform) decompose an image into four blocks, the approximation coefficients and three details coefficients, the details include horizontal, vertical and diagonal coefficients, and the following figure illustrates the DWT decomposing for an image:



Where LL: represents the approximation sub band.
LH: represents the horizontal details sub band .
HL: represents the vertical details sub band.
HH: represents the diagonal details sub band.

The lower frequencies in approximation sub band of the image should be preserved because the human visual system is very sensitive for the changes in this part, while the higher frequencies in the other sub bands can be approximated more loosely without much visible quality loss.

3. Absolute Moment Block Truncation Coding (AMBTC)

It's an improved, simple and fast variant of block truncation coding (BTC) method for image compression[4, 5]. This method was developed by Mitchell and Lema where the image is divided into non overlapping blocks with size 4x4 of pixels then for each block the mean ($\boldsymbol{m}$) is computed using Equation (1) as well as the higher mean ($\boldsymbol{m_H}$) and the lower mean ($\boldsymbol{m_L}$), which are used in the decompression stage, these two values is calculated using Equations (2) and (3), respectively.

$$m = \frac{1}{k}\sum_{i=1}^{k} x_i \qquad \ldots (1)$$

$$m_H = \frac{1}{n}\sum_{x_i \geq m}^{k} x_i \qquad \ldots (2)$$

$$m_L = \frac{1}{k-n}\sum_{x_i < m}^{k} x_i \qquad \ldots (3)$$

Where x_i represents the i^{th} pixel value of the image block, k is the total number of pixels in each block and n is the number of pixels whose gray level is greater than or equal to m.

After that the bit plane image is constructed by performing a two level quantization for all pixels in all blocks in the original image so that 1 is stored for all pixel value greater than or equal to m value and 0 is stored to pixels that have values less than m.

The encoder writes the bit plane image to the compressed file, as well as m_H and m_L values to use them later in the decompression stage. On the other hand, the decompression process is performed by substituting m_H values instead of 1's and m_L values instead of 0's in the bit plane image to reconstruct the compressed image.

4. Proposed Compression Method

The proposed method consists of two stages: in the first stage the image is converted from the spatial domain to frequency domain by applying 2D DWT, where the image signal is decomposed into four sub bands (LL, HL, LH and HH).

As indicated before, the LL sub band is the approximation representation for the image signal (specifying the low frequency parts of the image), LH sub band represents the horizontal details, HL sub band represents the vertical details and HH sub band represents the diagonal details. The second stage involves applying the AMBTC to LH, HL and HH sub bands without LL sub band, the three sub bands are processed as follows: dividing the sub bands into blocks with size 4x4 of pixels, and for each block m, m_H and m_L are computed using Equations (1),(2) and (3), respectively.

Then, a two level quantization is applied to build bit plane block, this is done by storing 1 to pixels values greater than or equal to m and storing 0 to the other pixels. This process is repeated to all blocks to construct the bit plane image of these parts.

After applying the AMBTC to LH, HL and HH, the encoder write the bit plane images and the higher mean vector and the lower mean vector of the three sub bands to the compressed file. The LL sub band is also wrote to the compressed file without any process because it represents the low frequencies of the image and the human visual system is sensitive to changes in that part.

In decompression stage, the compressed image is reconstructed by applying two steps. The first step is reconstructing the three sub bands LH, HL and HH, where each one is reconstructed by dividing the bit plane image of that part into 4x4 blocks and each block is reconstructed by replacing 1's with $\boldsymbol{m_H}$ and replacing 0's with $\boldsymbol{m_L}$ of each block.

After reconstructing LH, HL and HH parts, the second step of decompression is done by applying the inverse of DWT transform to LL and the three reconstructed sub bands (LH, HL and HH) to rebuild the compressed image.

4.1 Compression Algorithm

Stage1- Decompose the image into four sub bands (LL, LH, HL and HH) using one level 2D-DWT.

Stage2- For each (LH, HL and HH) sub band do

Step1- Divide the sub band into non overlapping blocks with size 4x4 of pixels.

Step2- For each block do

- Compute $\boldsymbol{m}$, $\boldsymbol{m_H}$ and $\boldsymbol{m_L}$ using Equations (1),(2) and (3), respectively.
- Construct the bit plane block by replacing the pixels that greater than or equal to $\boldsymbol{m}$ by 1 and the rest of pixels by 0.

Step3- Reconstruct the bit plane image of the sub band using the bit plane blocks.

4.2 Decompression Algorithm

Stage1- For each (LH, HL and HH) sub band do

Step1- Divide the bit plane sub band into non overlapping blocks with size 4x4 pixels.

Step2- For each bit plane block do

- For each pixel in block do
  If pixel= 1 then retrieved-pixel= $\boldsymbol{m_H}$
  else retrieved-pixel= $\boldsymbol{m_L}$.
- Construct the retrieved block using the retrieved pixels.

Step3- Reconstruct the decoded sub band using the retrieved blocks.

Stage2- Apply the inverse of DWT transform to LL and the three reconstructed sub bands (LH, HL and HH) to rebuild the compressed image.

5. Experimental Results

To evaluate the performance of the proposed image compression scheme, four standard monochrome images of size 256 X 256 pixels had been used ***"Lena", "Cupid "*** , ***"Man"*** and ***"Cat"*** which are shown Fig.1(a - d).

(a) Lena (b) Cupid

(c) Man (d) Cat

Fig. 1: The standard images used for experiment

These images are decomposed using one level 2D-DWT where the Haar filter of the DWT is used for that purpose. The reconstructed images of the proposed image compression scheme are given in Fig.2 (a - d)

(a) Lena

(b) Cupid

(c) Man

(d) Cat

Fig. 2: The reconstructed standard images using proposed scheme

Peak signal to noise ratio (PSNR) has been used to measure the difference between the original images and the reconstructed ones; PSNR is given by the following equation [6]:

$$PSNR = 10 Log_{10} \cdot \frac{255^2}{MSE} \qquad \dots (4)$$

Where MSE is the mean square error that is given by the following equation:

$$MSE = \frac{1}{H \times W} \sum_{i}^{H} \sum_{j}^{W} \left(x_{ij} - \bar{x}_{ij} \right)^2 \qquad \dots (5)$$

Where H and W are the dimensions of the images, x_{ij} is the original image pixel and x_{ij} is the reconstructed image pixel. Table (1) shows the PSNR of the two schemes.

Table (1): PSNR values of the two schemes

image	**AMBTC**	**Proposed scheme**
	PSNR (db)	**PSNR (db)**
Lena	**33**	**35**
Cupid	**30**	**33**
Man	**29**	**31**

Cat	**33**	**36**

The compression ratio of AMBTC is 0.25 and the compression ratio of the proposed method is 0.40, but as shown in Table (1) the PSNR values of the proposed method are higher and better than PSNR of the conventional AMBTC method.

6. Conclusions

A hybrid method for image compression has been presented using Discrete Wavelet Transform and Absolute Moment Block Truncation Coding. Based on the results obtained and detailed in the previous section, we conclude that DWT constitutes a powerful tool that can succeed in constructing image compression method. Using this transform with AMBTC improves the performance of the image compression system and a trade-off has been made to obtain a good quality reconstructed image with suitable amount of compression ratio. The experimental results shows that the proposed method gives higher PSNR values in compare with the conventional AMBTC and that can be illustrated in Fig.(3)

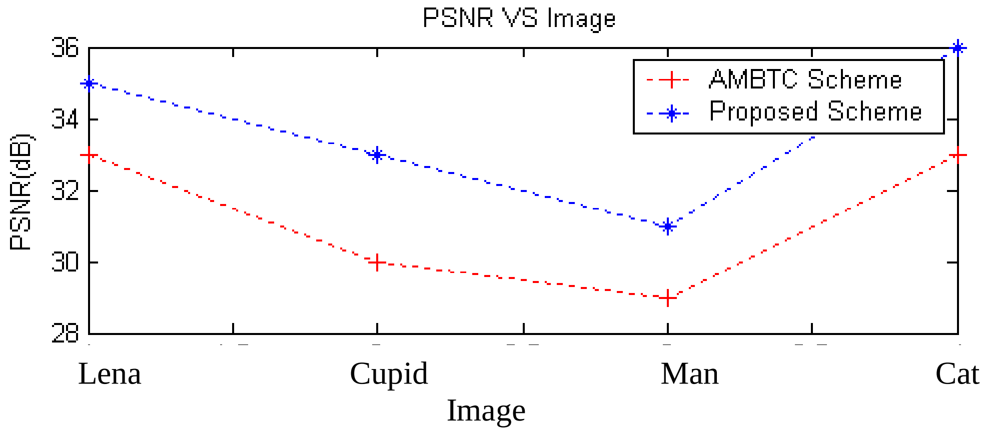


Fig.3: PSNR values versus the test images for both schemes

7. References

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طريقة مقترحة لضغط الصور باستخدام التحويل المويجي المتقطع وخوارزمية ترميز التقطيع الكتلي ذات الحد المطلق

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المستخلص

في هذا البحث، تم اقتراح طريقة هجينة لضغط الصور، هذه الطريقة تتألف من مرحلتين: الأولى تتضمن التحويل المويجي المتقطع الذي يستخدم لتحويل الصورة من المجال المكاني إلى المجال الترددي و المرحلة الثانية تتضمن خوارزمية الترميز المتقطع الكتلي ذات الحد المطلق AMBTC التي تستخدم لضغط بعض بيانات الصورة. و قد أظهرت النتائج التجريبية بان الطريقة المقترحة تمتلك انجازية جيدة جدا حيث إنها تعطي قيم PSNR أعلى مع قيم مناسبة لنسب الضغط مقارنة مع خوارزمية AMBTC التقليدية.

الكلمات المفتاحية: ضغط الصور، التحويل المويجي المتقطع، AMBTC، PSNR.