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Interpolative Absolute Block Truncation Coding for Image Compression

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Abstract: In this paper, an interpolation technique of nearest neighbour base is proposed along with absolute block truncation coding that exploited the spatial domain of low resolution image, and then reversely reconstruct the up layers hierarchically. The results showed the superior performance of compression ratio and image quality compared to traditional absolute block truncation coding.

Keywords: image compression, absolute block truncation coding and interpolation technique

1. Introduction
Compression techniques represent the cornerstone of all the multimedia areas, to efficiently compress large data files of huge bytes consumption of image, video, audio and audio.
Image compression techniques play a vital role in our live, resembling a heart for enabling technology [1], which simply based on utilizing the redundancy(s) of statistical base and/or human visual system (HVS) base, for the former one encompass the interpixel and coding redundancies, while for the latter one means the psychovisual redundancy, due to the redundancy type(s) exploited image compression classified into lossy and lossless. Reviews of image compression techniques can be found [2-7].
Block Truncation Coding (BTC) an effective lossy technique that characterized by simplicity, symmetry of encoder/decoder and efficient compression ratio due to the ability to represent the image information using the mean and standard deviation, thus sometimes referred to as moment-preserving block truncation because it preserves the first and second moments of each image block, but the main drawbacks of this technique are blocking effects and edge degradation [8].
In this paper, a simple method for compressing gray images is introduced that based on exploited the absolute block truncation coding (*ABTC*) and interpolation technique of multilayer(s) scheme that efficiently improves the compression performance. The rest of paper organized as follows, section 2 contains comprehensive clarification of the proposed system; the results for the proposed system and the conclusions, is given in sections 3 and 4, respectively.

2. The Proposed System

The implementation of the proposed system is explained in the following steps as shown in figure (1). The general idea behind the work of interpolation scheme base can be found in details in [9], which utilized the traditional prediction coding techniques.

Step 1: Load the input uncompressed gray image Y_0 of *BMP* format of size $N\times N$ that corresponds to high resolution image of size *256×256* that resemble to $layer_0$ or *root* of the tree.

Step 2: Apply the interpolation technique of multiresolution scheme through shrinking and enlarging base. Different interpolation techniques can be utilized ranging from the simple and easy, like the nearest neighbour approach, to more accurate ones like the bi-linear technique adopted in this work, to complex ones like higher order interpolation. The choice between them depends on the speed, computations and quality desired [1]. In this paper the simple popular nearest neighbour interpolation techniques used, where the interpolation technique works by creating the medium resolution image Y_1 and low resolution image Y_2 each of size ($N/2\times N/2$) and ($N/4\times N/4$) respectively corresponds to $layer_1$ and $layer_2$, namely create the smaller Y_1 of size *128×128* from the original Y_0 and then create Y_2 of size *64×64* from the shrinked Y_1 [10].

Step 3: Perform the absolute block truncation coding (*ABTC*) on the low resolution image Y_2 ($layer_2$) of two levels (1 bit) quantizer of moment base, using the following sub steps [11]:

1. Computer first moment value, namely mean, for each block of size ($n\times n$), then the image block values grouped into two ranges of values, namely upper range is those gray levels which are greater than the block average gray level ($\bar{x}$) and the remaining brought into the lower range. The mean of higher range X_H and the lower range X_L are calculated as:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} Y2_i \qquad (1)$$

Where Y_2i represents the i^{th} pixel value of the low resolution image block ($layer_2$ image block) and n is the total number of pixels in that block.

$$x_H = \frac{1}{K}\sum_{xi>\bar{x}}^{n} x_i \qquad (2)$$

$$x_L = \frac{1}{(n)^2 - K}\sum_{xi<\bar{x}}^{n} x_i \qquad (3)$$

Here K is the number of pixels whose gray level is greater than $\bar{x}$, and n^2 is the block size.

2. Create the Binary image block, denoted by B (two-level bit plane image) that is obtained by comparing each value Y_2i with the threshold value (i.e., block mean), in other words'1'used to represent a pixel whose gray level is grater than or equal to mean ($\bar{x}$) and '0' to represent a pixel whose gray level is less than mean ($\bar{x}$).

$$B = \begin{cases} 1 & \text{if } Y2i \geq \bar{x} \\ 0 & \text{if } Y2i \langle \bar{x} \end{cases} \qquad (4)$$

3. Apply entropy encoder of the compressed information of low resolution image (*ABTC* binary image and coefficients) using run length coding of binary image and LZW to X_H and X_L respectively.

4. Reconstruct the compressed approximated image of low resolution base, an image block $\tilde{Y}_2$ is reconstructed by replacing the `1' s with X_H and the '0"s by X_L.

$$\tilde{Y}_2 = \begin{cases} X_L & B = 0 \\ X_H & B = 1 \end{cases} \qquad (5)$$

Step 4: Use lower resolution image information ($layer_2$) to reconstruct the medium layer ($layer_1$), such as:

1. Apply the nearest neighbour interpolation concept to create the enlarged image $InMed[\tilde{Y}_2]$ of medium size resolution *128×128* from the approximated image $\tilde{Y}_2$ of size *64×64*.

2. Find the first residual image as a difference between the original shrinked image of medium resolution Y_1 and the interpolated one from the step above.

$$e_1 = Y_1 - InMed[\tilde{Y}_2] \qquad (6)$$

3. Quantize/dequantized the first residual above using the simple uniform scalar quantizer:

$$e_1Q = round(\frac{e_1}{QS_{e_1}}) \rightarrow e_1D = e_1Q \times QS_{e1} \qquad (7)$$

4. Find the approximated medium resolution image $\tilde{Y}_1$ as a sum of interpolated one $In_{Med}[\tilde{Y}_2]$ along with the dequantized residual, such as:

$$\tilde{Y}_1 = In_{Med}[\tilde{Y}_2] + e_1D \qquad (8)$$

Step 5: Build the high image resolution (*layer$_0$* or *root*) of same size as the original using the medium constructed layer above (*layer$_1$*), such as:

1. Use the nearest neighbour interpolation concept to create the enlarged image *InHgt* [$\tilde{Y}_1$] of high size resolution *256×256* from the approximated image $\tilde{Y}_1$ of size *128×128* (see, Step 4 above).
2. Find the second residual image as a difference between the original image of high resolution Y_0 and the interpolated one resultant from the step above.

$$e_0 = Y_0 - In_{Hgt}[\tilde{Y}_1] \qquad (9)$$

3. Quantize/dequantized the second residual image using the simple uniform scalar quantizer, such as:

$$e_0Q = round(\frac{e_0}{QS_{e_0}}) \rightarrow e_0D = e_0Q \times QS_{e0} \qquad (10)$$

4. Find the approximated high resolution image $\tilde{Y}_0$ as a sum of interpolated one $In_{Hgt}[\tilde{Y}_1]$ along with the dequantized residual image, such as:

$$\tilde{Y}_0 = In_{Hgt}[\tilde{Y}_1] + e_0D \qquad (11)$$

In addition to low resolution image information (*ABTC* binary image & coefficients), the dequantized differences of medium and high resolutions layer respectively, encoded using the LZW techniques.

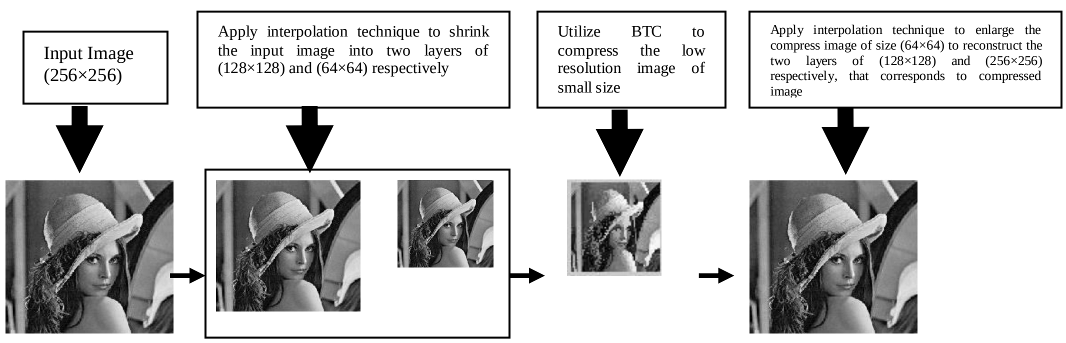

Fig. (1): The proposed compression system structure.

3. Experimental & Results

In order to evaluate the performance of the proposed compression technique compared to the *ABTC* method that applied to standard images as shown in figure 2 also the *4×4* block size used along with various quantization level/steps of first and second residual images.

Table (1) illustrated the results in terms of objective fidelity criteria of Peak Signal to Noise Ratio (*PSNR*) (see equation 12) between the original image $Y_0$and the decoded (compressed) image $\tilde{Y}_0$, and the Compression Ratio (*CR*) (see equation13).

$$PSNR = 10.\log_{10}\left[\frac{(255)^2}{\frac{1}{N \times N}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1}\left[\tilde{Y}_0(x,y) - Y_0(x,y)\right]^2}\right] \qquad (12)$$

$$CompressionRatio = \frac{Size of Original\ Image}{Size of Compressed Information} \quad (13)$$

a b

Fig. (2): Overview of the tested images (a) Lena image, (b) Pepper image, all images of size 256×256, gray scale images.

ABTC with higher image quality. This is due to utilization the interpolation technique that leads to the construction of low resolution image of small error quality that reconstructed hierarchically.

Certainly, the quality of the decoded image is improves as the number of quantization levels of both of the residual images of two layers ($layer_2$ and $layer_1$). The main disadvantage of increasing the quantization levels, however, lies in increasing the size of the compressed information. It is a trade-off between the desired quality and the consumption of bytes; the higher the quality required, the larger the number of quantization levels that must be used. While the traditional *ABTC* affected by the mean value corresponds to threshold value (i.e., mean) .
Lastly, this technique work by exploiting the spatial domain base, which implicitly means, the results varies according to image details, where for simple image details higher performance achieved than higher or complex image details.

Table 1: Comparison performance between traditional ABTC and Interpolative ABTC techniques for tested images, where all the images are square gray scale images of size 256x256 pixels of 8 bit/per pixel.

Image	***Block Size of 4x4ABTC***		***Block Size of 4x4 of Interpolation ABTC***			
	CR	***PSNR***	***Qant. Step of 1st residual***	***Qant. Step of 2nd residual***	***CR***	***PSNR***
Lena	10.3160	29.3174	4	16	19.4551	30.5710
			4	32	18.1911	35.9318
			8	16	17.1744	31.5703
			8	32	16.2854	37.1277
			16	16	15.3333	31.4101
			16	32	13.9800	38.1150
			32	32	13.6860	39.0007
			32	64	12.2587	43.3535
Pepper	13.0591	28.1333	4	16	23.2382	29.7098
			4	32	19.0469	34.9768
			8	16	21.1284	30.5188
			8	32	18.4352	35.9088
			16	16	20.0205	31.1552
			16	32	17.0176	36.1466
			32	32	16.0803	36.8188
			32	64	15.6312	42.6730

4. Conclusions

It is obvious that the proposed technique of interpolation base or multiresolution layers, that reversely uses the hierarchical down layers to reconstruct the up layers, improves the performance compared to traditional *ABTC*, even here the simple popular interpolation technique of nearest neighbour used.

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