Low computations in compression image schemes using Cache codebook based on Weber's law

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Abstract

In this paper, we have employed a computation of three technique to reduce the computational complexity and bit rate for compressed image. These techniques are bit plane coding based on two absolute values, vector quantization VQ technique using Cache codebook and Weber's low condition. The experimental results show that the proposed techniques achieve reduce the storage size of bit plane and low computational complexity.

Keywords: Bit plane**,** Vector Quantized method, Cache codebook, Weber's law condition.

خفض الحسابات في طرق ضغطُ الصور باستخدام كتاب تشفير Cache بالاستناد على قانونِ ويبير

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الخلاصة:

في هذا البحث، استخدمنا ثلاثة تقنيات لتَخفيض التعقيدِ الحسابِي وتقليل نسبة الضغط للصورةِ المَضْغُوطةِ. هذه التقنياتِ bit plane coding مستندة على القيمتين المطلقين وتقنية ال VQ باستعمال كتاب تشفير Cache وشرط قانون ويبر. من النتائِجَ التجريبِية نلاحظ أنّ التقنيات المقترَحةَ تعمل على تخفيض حجم الخزن مع تقليل التعقيد الحسابِي.

Introduction:

Image compression methods assist to reduce the store space or transmit the image data by changing the represented way of the image. There are many methods for compressing image [1] such us the BTC method for monochrome image compression which was introduced by Delp and Mitchell it is a simple image compression method [2]. BTC has the advantage of being easy to implement compared to vector quantization and transform coding [3-5]. It achieves 2 bits per pixel (bpp) with low computational complexity. Lema and Mitchell presented a simple and fast variant of BTC called Absolute Moment Block Truncation Coding (AMBTC). It preserves the higher mean and lower mean of the blocks[3]. However the bit rate achieved is 2 bpp which is same as in the original BTC. Since the bit rate of the AMBTC is relatively high when compared to other image compression techniques, many modification of AMBTC have been proposed to further reduce the bit rate.

Udipikar and Raina introduced BTC image compression using Vector Quantization (VQ) and the bit rate achieved in the range of 1.0-1.5 bpp [3,6]. The hybrid BTC / VQ techniques reduce the bit rate, but we need low computational complexity with more compression. In this paper, we introduced a simple strategy to reduce the storage size of bit plane, low computational complexity and low computation for encoding the code book by using a modified AMBTC algorithm which used block classified depending on Weber's low. Hence the improvements on AMBTC are continuing to increase the compression (low bit rate) and low computational complexity by keeping

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the image quality to acceptable limit. This compressor employs four techniques, where these techniques are bit plane coding based on two absolute moments values, vector quantization VQ using Cache codebook based on Weber's low [6]. From the experimental results, we found that the proposed scheme gives good image quality with low computational complexity and with low bit rate.

Absolute Moment Block Truncation Coding (AMBTC):

AMBTC is an encoding technique that preserves the spatial details of digital images while achieving a reasonable compression ratio. It is an improved version of BTC, obtained by preserving absolute moments instead of standard moments [3,5].

Vector quantization:

Vector quantization is a very popular data compression method, the main advantages of this method are; it provides high compression ratio and simple decoding process (look-up table) [3]. In this paper, this method is used to code high detail bit map (binary block which is the output from AMBTC).

This method can described as a look-up matching process, where an input vector (i.e. binary block in bit map) is represented by the index of the codeword in the codebook which achieves the best matching with this bit map block [5,6].

Let *CB* be a given codebook. Let x_i be an input vector and $CW_1, CW_2, CW_3, \cdots, CW_k$, where *K* is the number of code words which stored in the codebook. the minimum square distortion for the vector x_i is found:

$$d_i = d_{\min(x_i, CW_j)} \tag{1}$$

Block classification:

Natural image contains regions of, high detail blocks and low detail blocks which include areas of constant intensity (i.e. *I*=0) or slowly varying intensity $I \approx Io$), these are usually classified by using method to defining blocks type, in this paper, A simple algorithm based on condition of Weber-Fechner's law is proposed to distinguish low and constant detail blocks from high detail blocks in the original image.

Weber-Fechner law:

Weber's law states that, it is the ratio of the difference between the max and min luminance values to min luminance value is denoted by constant *"C"* [3].

$$C = \frac{I - I_o}{I_o} \tag{2}$$

Where *C* is known a Weber fraction, *C* = 0.01 ... 0.02.

In this work let the original intensity is I_o which the eye is adapted, and the change in the intensity is $\Delta I = I - I_o$), the description of the relation between the change of intensity and the original intensity I_o is constant.

(ΔI / I_o) = Constant (3)

In this paper, according to this law, for each block, *ΔI* is founded from the difference between the two reconstructed values produced from AMBTC method. The block is classified as a uniform block when $(\Delta I / I_o) \leq C$, Otherwise, it is non uniform block.

Description of Cache codebook (CCB):

This method depends on the correlation among neighboring vectors on the image blocks, the quantized uses only a few of the available codewords to code a number of successive input image blocks. Thus, a codeword which has just been used in likely to be used again to code the following incoming vectors, therefore, the *K* most newly used codewords can be stored in a 'Cache codebook' (CCB) and among the code words the closest vector to the input vector can be search for. The search continues in the main codebook only when the distortion be greater than a given threshold (σ) [6].

The Cache codebook (CCB) performance is described as follows:

Let *CB* be a given codebook. Let x_i be an input vector and $CW_1, CW_2, CW_3, \cdots, CW_k$, the *K* most recently used codewords which stored in the CCB. (σ) is a given square distortion threshold.

Let $d_i = d_{\min(x_i, CW_j)}$ Be the minimum square distortion for the vector x_i in the CCB.

If $d_i <= \sigma$, the codeword found in the CCB is accepted and its index sent out to the decoder, otherwise the search continues in the main codebook and the new codeword enters the CCB, from which the least recently used codeword is deleted from the main codebook.

Proposed Scheme:

The proposed compression scheme makes use of bit plane coding based on two absolute values, vector quantization VQ using Cache codebook and Weber's low. The bit plane coding divides the given image in to non overlapping blocks. Here, for each image block, we use the difference between the higher mean and the lower mean of using AMBTC method as controlling value to segment the block of image.   According to the Weber-Fechner condition, if the difference between the higher mean and the lower mean is less than a threshold value (*C*) (i.e. Weber's fraction), the block is classified as low or constant details block, then encode block with only the block mean (M), and use "0" as an indicator bit as prefix code for decoding proposed then mean of block and "0" are transmitted. At the time of decoding bit plane omitted blocks are replaced by the respective block means. Otherwise the difference between the higher mean and the lower mean is high than a threshold value then the block is classified as high details block, then use "1" as an indicator bit as prefix code for decoding proposed then the two reconstruction level (L and H) and for more encoding the pit map of this block we use VQ method using Cache codebook to code this block then the two reconstruction level and index of the codeword which achieved the best match with the input bit map block are transmitted.

The interpolative technique is the method that drops partly of the bit plane at the time of encoding and at the time of decoding. The detailed steps involved in the compression process are as Figure-1:
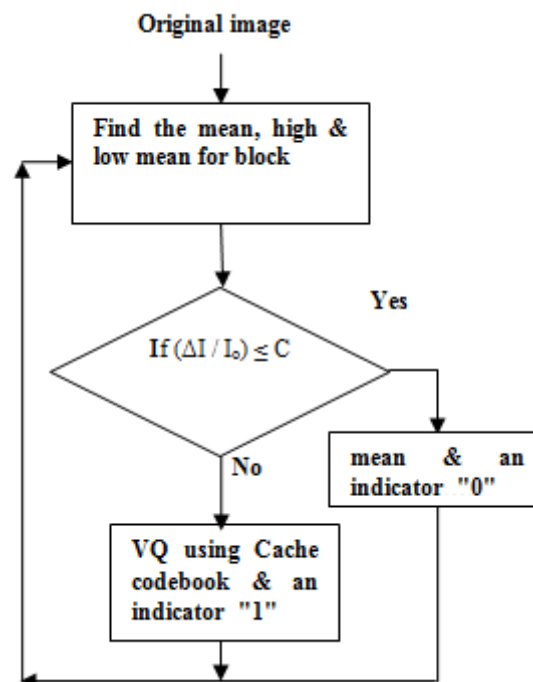

Figure 1- The diagram of the mentioned algorithm

Results and discussion:

While implementing this algorithm we implement the AMBTC (i.e. find the tow reconstruction values and bit map for block) at different block size, we have take two threshold values. To find our optimum threshold values for our image compression schemes, we have applied our image compression schemes on MOON image and compare it with using AMBTC method and AMBTC based on Weber-Fechner condition.

Using the results given in Table-1, we have decided to take the threshold *C*=.01 and *C*=.02, so as to get a reasonable good quality image when *C*=.01 more than when *C*=.02, but Low bit rat when *C*=.02.

The main advantage that could be expected is to improve the compression ratios (decreasing in bit rate) with low computational complexity by coding the uniform blocks like backgrounds or the low detailed block, which can be classified depending on Weber-Fechner condition (*C*=.01 and *C*=.02)

then transmit the mean of block only on the channel, while the high detailed block like non uniform is coded by AMBTC and our proposed method, then transmit the tow reconstruction values and bit map for block, for more compression in our proposed method the bit map is coded by VQ method using Cache codebook then transmit the two reconstruction values and index for this block, this idea is lead to decrease the coding time, decrease in the bit rate, decrease in number of computation, with good reconstructed image quality see Figure-3.

Conclusions:

In this paper, we have developed a low computational complexity with high compression ratio using bit plane coding based on two absolute values, vector quantization VQ using Cache codebook and Weber's low condition. In this paper we introduced a simple strategy to reduce the storage size of bit plane, low computational complexity and the total calculation time at the transmitter is significantly reduced. the experimental results show that the proposed schemes achieve good results, where the reconstructed image quality obtained using proposed algorithm are good when compared it to those obtainable with other existing AMBTC algorithms and AMBTC based on Weber-Fechner condition.

Table 1- PSNR and bit rate values for original AMBTC, AMBTC based on Weber-Fechner condition and AMBTC+VQ using Cache codebook based on Weber-Fechner condition , the test image are 64x64 pixels.

Block size	AMBTC		AMBTC based on Weber-Fechner condition C=0.01		AMBTC+VQ using Cache codebook based on Weber-Fechner condition			
					C=.01		C=.02	
	B.r	PSNR	B.r	PSNR	B.r	PSNR	B.r	PSNR
4x4	2	31.3	1.02	29.2	.69	28.3	.49	26.9
8x8	1.25	28.1	.82	27.1	.59	26.5	.31	25.1
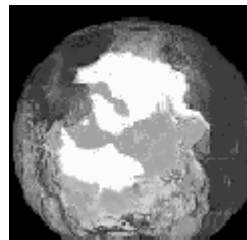
Figure 2- Original image

a.   b.   c.   d.
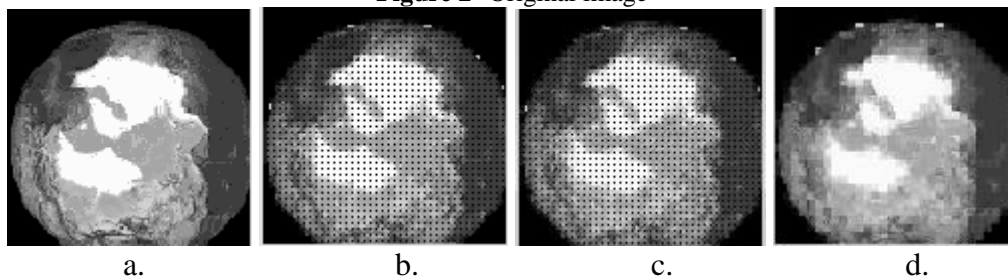
Figure 3- Coding decoding image, block size 4 x4

   a. Using AMBTC**.**

   b. Using AMBTC based on Weber-
      Fechner condition C=.01**.**

   c. Using AMBTC+VQ using Cache codebook based on Weber-
      Fechner condition C=.01**.**

   d. AMBTC+VQ using Cache codebook based on Weber-Fechner condition
      C=.02.

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