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The Method of Image Auto-Block Coding

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Abstract: In this study an auto-block coding method was proposed. This method regulates the number of quantization levels in each block automatically according to its characteristics. The method uses the mean quantified level quantification, two-level quantification and four-level quantification integrated multi-level approach to quantify the image coding image. It can recover the detail information of the image accurately and improve the quality of decoding image. This study introduces the principle of the auto-block coding method in detail and compare with two-level block coding method. Experimental results with MATLAB® are provided to demonstrate the effectiveness of the proposed method.

Key words: Block Truncation Coding (BTC), quantization level, auto-block, multi-level quantification

INSTRUCTION

Block Truncation Coding (BTC) method is applied in the field of image compression of its simple coding method, fast calculation, image restoration quality and the channel BER is not sensitive. After 1979, researchers proposed block truncation coding algorithm a number of improved algorithms appeared and these methods were used in many field such as image transmission (Chang *et al*., 2001), digital Rights Management (Tu and Hsu, 2005), limited-color display (Pei and Cheng, 2006) and data hiding (Chang *et al*., 2008). But the disadvantage of the block truncation coding method was that there was blocking effect on the edge because the single two-block coding can cause the value jump on the edge and the compression ratio was lower than the other compression methods. So, there were many improved methods in order to reduce the error on the edge and improve the compression quality (Skarbek and Pietrowcew, 2006; Wang and Neuvo, 2005; Heng-fu *et al*., 2009; Guofang and Wang, 1999). In order to improve the quality of decoding image restoration, it may be based on changes of the value of the image pixel intensity automatically adjust the number of quantization levels to improve the quality of compressed image reconstruction. This paper proposed an auto-block coding method. Experiments show that this method can improve the quality of decoding image restoration.

AUTO-BLOCK TRUNCATION CODING

Encoding principles:

- Auto-block coding method will first divide the input image into non-overlapping blocks, each block is composed of X by n pixel, n take 16, one of the sub-block is:

$$X = \begin{bmatrix} x_{11} & x_{12} & x_{13} & x_{14} \\ x_{21} & x_{22} & x_{23} & x_{24} \\ x_{31} & x_{32} & x_{33} & x_{34} \\ x_{41} & x_{42} & x_{43} & x_{44} \end{bmatrix} \quad (1)$$

- Calculate the difference between the maximum and minimum of pixel block, $\Delta = X_{max}$-X_{min} and compares Ä with the two thresholds $\lambda\lambda_1$ and λ_2, the result of comparing will divides the image block into three kinds of blocks of smooth pixel values, blocks of uniform changes in pixel value and blocks of rapid changes in pixel value
- If $\Delta \le \lambda_1$, λ_1 usually takes 6~10, coding the image block with average coding method, replace the image block with the average of all pixel value
- If $\lambda_1 \le \Delta \le \lambda_2$, λ_2 usually takes 20~40, coding the image block with two-level quantization coding method, calculate high level, low level and a binary bitmap

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- If $\Delta>\lambda_2$, coding the image block with four-level quantization coding method, calculate the four quantitative levels and four quantitative bitmaps
- In order to distinguish three kinds of circumstances of the coding method, marks the coding results, the mean code block only to send the tag-bit and the mean; Two-level code block send tag-bit, two quantitative level and quantify bitmap; Four-level code block send tag-bit, four-level quantization and four quantify bitmap. Mean coding block tag-bits is 00, two-level code block tag-bits is 01, four-level code block tag-bits is 10

After coding, the sending order of tag-bit, quantization level and quantization bitmap are shown in Fig. 1.

Decoding principles: The receiver judge the type of encoding block according to the received flag, If the received tag-bit is 00, the received block is considered to be mean-quantization block, using the received mean value instead of the whole image pixel value to restore the pixel block; If the received tag-bit is 01, the received block is considered to be two-level quantization block, according to the position of 0 and 1 in binary bitmap, replace the Fig. 1 location with high level and replace the value 0 position with the low-level. If the received tag-bit is 10, the received block is considered to be four-level quantization block, the position 00, 01, 10, 11 will be restored with four quantization levels according to the four-level bitmap in the bitmap.

Design of two-level quantizer: Set threshold T_0, divide the pixel in the block into two groups, the pixel in one group are all higher than T_0, the pixel in another group are lower than T_0. Using a binary bitmap P(i, j) to represent the output bit of two-level block truncation coding, which X(i, j) represent the gray value in the position of (i, j) in the block X. Finally, the calculate two gray value a and b($a \le b$) in each block, when P(i, j) = L, the pixel X(i, j) is quantified as b, otherwise is quantified as a:

$$T_0 = \bar{x} = \frac{1}{n \times n}\sum_{i=1}^{n}\sum_{j=1}^{n} x_{ij} \tag{2}$$

$$P_{ij} = \begin{cases} 1, \text{ if } x_{ij} > \bar{x} \\ 0, \text{ otherwise} \end{cases} \tag{3}$$

Tag-bit	Quantization level	Quantization bitmap

Fig. 1: The order of the sending message

$$a = \frac{\sum X_L}{N_0} \tag{4}$$

$$b = \frac{\sum X_H}{N_1} \tag{5}$$

where, X_L represent the pixels which are lower than threshold in the block, N_0 is the number of X_L. X_H represent the pixels which are higher than threshold in the block, N_1 is the number of X_H.

Design of four-level quantizer: Set dynamic threshold T_L, T_M and T_H and four quantified level values. The pixels in the block X are divided into four groups by three dynamic threshold and using P(i, j) to represent the output bit of four-level block truncation coding, such as Eq. 6 shown. μ1, μ2, μ3, μ4 respectively represent the decoding values of the four quantization levels:

$$Q(i,j) = \begin{cases} 00, & \text{if } X(i,j) \le T_L \\ 01, & \text{if } T_L < X(i,j) \le T_M \\ 10, & \text{if } T_M < X(i,j) \le T_H \\ 11, & \text{if } X(i,j) > T_H \end{cases} \tag{6}$$

Three dynamic threshold of the strike is divided into three steps, as shown in Fig. 2.

Firstly, the method to seek the threshold values T_1 and the two-level quantizer threshold value T_0 are in the same way, such as Eq. 2. The whole pixels in the block are divided into two parts by T_1, secondly, using formula of the two-level quantizer again to seek two dynamic threshold T_L and T_H in the two groups respectively, the whole block is divided into three groups by two dynamic threshold. Finally, using formula of the two-level quantizer again to seek dynamic threshold T_M in the middle area where values are higher than T_L and lower than T_H.

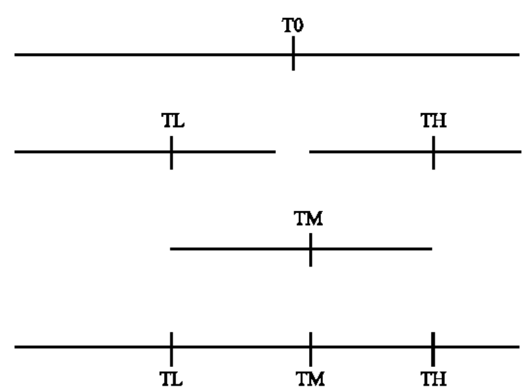

Fig. 2: The step of calculating threshold

The block is divided into four groups G_1, G_2, G_3, G_4 by three dynamic thresholds. The quantitative level μ_i in each part is mean pixel value for each group.

$$\mu_i = \frac{1}{n}\sum \chi_i \qquad \chi_i \in G_i \tag{7}$$

When Q(i, j)) = 00, X(i, j) is quantified as μ1, when Q(i, j) = 01, X(i, j)) is quantified as μ_2, when Q(i, j) = 10, X(i, j) is quantified as μ_3, when Q(i, j) = 11, X(i, j) is quantified as μ_4.

SIMULATION EXPERIMENT

Here, the image contrast results of traditional block truncation coding and auto-block image coding method of coding are given.

Mean Square Error (MSE): {f(m, n)} indicates the original image, $\{\hat{f}(m,n)\}$ indicates the decoding image. Assume the size of the two images is M×N, the mean square error between them is:

$$MSE = \frac{1}{MN}\sum_{m=1}^{M}\sum_{n=1}^{N}[f(m,n) - \hat{f}(m,n)]^2 \tag{8}$$

Peak Signal to Noise Ratio (PSNR)

$$PSNR = 10\lg\left\{\frac{255\times 255}{\frac{1}{MN}\sum_{m=1}^{M}\sum_{n=1}^{N}[f(m,n) - \hat{f}(m,n)]^2}\right\} \tag{9}$$

Two dimensions of the Tree image are selected to do the simulation experiment which is separate two-level block truncation coding and auto-block coding. Figure 3 is the original image of 512×512 dimension, Figure 4a and b show the decoded image of the separately two-level block truncation coding and the decoded image of auto-block Coding with the two thresholds of (8, 30).

Fig. 3: The original image before coding

Table 1 show the peak signal to noise ratio comparison result of two different sizes images of the two images with the two-level block truncation coding and auto-block coding.

Experimental results show that the peak signal to noise ratio of auto-block coding quantization recovery image is better than two-level quantization recovery image and can reflect the real information in details better. And the value of the peak signal to noise ratio increase with the decreasing of λ_1 and λ_2. Especially the decrease of λ_2

Table 1: PSNR comparison result of the two methods

	Size	
Quantitative method	512×512	256×256
Two-level BTC	35.42	35.73
Auto-block coding λ_1= 10, λ_2= 40	36.96	37.51
Auto-block coding λ_1= 8, λ_2= 30	38.56	38.72
Auto-block coding λ_1= 6, λ_2= 20	39.54	39.87

Fig. 4: (a, b) The decoding images after two-block coding and auto-block coding

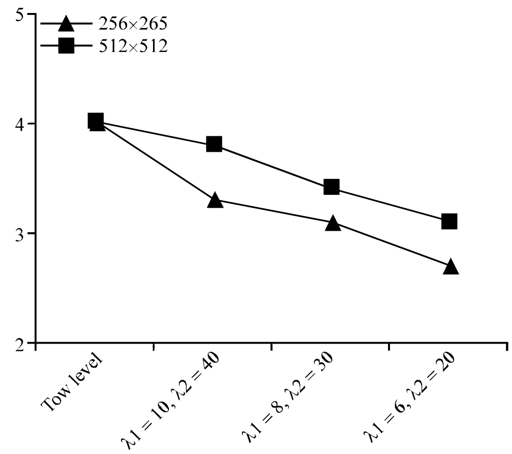

Fig. 5: Compression ratio comparison

will increase the number of the four-level quantization block, the peak signal to noise ratio is even greater. But it will also affect the compression rate and increase the number of bits.

The compression ratio of two-level block truncation coding method is generally 1:4. Auto-block coding method sacrifices a certain amount of compression ratio to achieving a better visual effect.

Figure 5 shows the results that the two-level block truncation coding compared with three kinds of auto-block coding compression. Our experiments selected 512×512 and 256×256 two-sized Tree images, which calculated compression ratio of four encoding methods.

The data in Fig. 5 show that the compression rate of the auto-block coding has slightly less than the one of the two-level block truncation coding. However, it doesn't have little lower in values of λ1 and λ2 which are respectively 10 and 40, the compression rate in 512×512 Tree image is close to two-level block truncation coding compression ratio.

CONCLUSION

This study presents an auto-block coding method. Experimental results showed that auto-block coding method has better image compression than the two-level block truncation coding method, which has improved in peak signal to noise ratio. But it doesn't have much effect on the right compression ration and the compression ratio of the improved method is lower then four. It could be observed that the compression ratio can be changed when the values of λ_1 and λ_2, so how to improve the compression is another problem we can work on to perfect the method.

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