Astronomi cal Color Image Compression Using Multilevel Block Truncation Coding –Modified Vector Quantization Technique

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Abstract

A common approach to the color image compression was started by transform the red, green, and blue or (RGB) color model to a desire color model, then applying compression techniques, and finally retransform the results into RGB model In this paper, a new color image compression method based on multilevel block truncation coding (MBTC) and vector quantization is presented. By exploiting human visual system response for color, bit allocation process is implemented to distribute the bits for encoding in more effective away.

To improve the performance efficiency of vector quantization (VQ), modifications have been implemented. To combines the simple computational and edge preservation properties of MBTC with high compression ratio and good subjective performance of modified VQ, a hybrid MBTC- modified VQ color image compression method is presented. The analysis results have indicated the performance of the suggested method is better, where the constructed images are less distorted and compressed with higher factor(59:1).

I. Introduction

Vector quantization (VQ) and block truncation coding (BTC) technique have been used for many years for coding digital images. Detailed discussion of VQ, BTC and its implementation to digital image compression can be found in [1, 2]. However, a reproduced image using VQ or BTC suffers from edge degradation. Cheng and Tsai [3] proposed an adaptive image compression algorithm using multilevel BTC method. In this algorithm, the input image is partitioned into blocks with variable sizes, and the gray values of each block are adaptively quantized to be one, two, or four levels according to local image statistical characteristics.

Wen and Shen [4] proposed a new multilevel BTC with a genetic algorithm. Yan and Young [5]introduced the learning vector quantization algorithm which applied to the data from optical, x ray, and infrared bands, and tested it with different samples for classifying astronomical objects. Mohamed and Fahamy [6] used VQ-BTC technique, VQ is used to encode the low-detail block while a modification of BTC is used for high detail block. In this paper, a color image compression method using multilevel BTC and modified VQ is proposed. Most color images are recorded in RGB model, which is the most well known color model. However, RGB model is not suited for image processing purpose. For compression, a luminance-chrominance representation is considered superior to the RGB representation. Therefore, RGB images are transformed to one of the luminance-chrominance. The luminance component represents the intensity of the image and look likes a gray scale version while the chrominance components represent the color information in the image[7;8].

In this work, RGB image is transformed to the luminance-chrominance representation(such as YIQ), performing the compression process, and then transform back to RGB model because displays are most often provided output image with direct RGB model.

II. Multilevel BTC method (MBTC)

The conventional BTC method uses a two level moment preserving quantizer that adapts to local properties of the image, and it tends to produce jagged edges in the reconstructed images, due to insufficient quantization levels. Therefore, it is reasonable to introduce more quantization levels to encode the blocks for better visual quality. For this reason, a multilevel block truncation coding (MBTC) method is used. The output of the MBTC method consists of a multilevel plane, each level specifies certain quantization level (A, B, C, D…etc).

The first step in this method by calculating of the mean value for each block, and then the histogram will be partitioned into two regions by considering the mean value as partition level. As a next step, for each partition region its mean will be calculated and then partitioned into other smaller sub regions. The partition process will be repeated until getting the suitable number of sub regions. For example, assume the histogram is ranged between (0) to (L-1) and the mean value of histogram equal M_0, then the histogram is partitioned into two intervals such that the two partitions are (0 to M_0) and (M_0+1 to L-1), the partitioning stages will be repeated by using a set of means M_k until the number of selected partitions equal the required number. On the contrary, if the considered block is smooth enough, it is not necessary to code it with more than two quantization levels; the pixels of the uniform block are estimated by its mean. In our method MBTC, we utilized the standard deviation as criterion to determine the degree of uniformity of each block. A single value (the mean) is used to encode each uniform block, while four-quantization levels (2bits) are used to encode each non-uniform block of the image [9].

For compression, a luminance-chrominance representation is considered superior to the RGB representation, where the luminance component represents the intensity of the image look likes a gray- scale version, and the chrominance components represent the color information The advantage of separating luminance component from chrominance component is that, we can distribute the bits for encoding in more effective away. Bit allocation is the problem of assigning bit rates to a number of subband coding systems. It is well known that the luminance component has higher variance than the chrominance components, and this higher variance means that it has more information and ought to be allocating more bits. Most of the studies decided an arbitrary number of more bits that are required. In the present work, we allocate the bits to be proportional to the logarithm of the variance for each component according to the following equations:

$$\alpha\log\sigma_L^2 + W_1\alpha\log\sigma_{C1}^2 + W_2\alpha\log\sigma_{C2}^2 = N_B \qquad (1)$$

where,

N_B represents the number of desired bits.

W_1 & W_2 represent the relative weighting of the chrominance components

$\sigma_L^2, \sigma_{C1}^2, and\, \sigma_{C2}^2$ represent the variances for luminance and both chrominance components, respectively.

By calculating the parameter (α) and given weighting for both chrominance components, we allocate the bits as follow:

$$Bits_L = \alpha\log\sigma_L^2 \qquad (2)$$

$$Bits_{C1} = W_1\alpha\log\sigma_{C1}^2 \qquad (3)$$

$$Bits_{C2} = W_2\alpha\log\sigma_{C2}^2 \qquad (4)$$

where,

$Bits_L$ is the number of bits for the luminance component.

$Bits_{C1}$ is the number of bits for the first chrominance component.

$Bits_{C2}$ is the number of bits for the second chrominance component.

III. Modified Vector Quantization (MVQ)

The designed of optimum VQ is involved with building the codebook such that the mean distortion result from using N-reproduction vectors is lower than that created by using any other set of vectors. One of the most extensively used and studied algorithms, is that proposed by Lindo, Buzo, and Gray (1980)[10]. This algorithm is commonly referred to as LBG algorithm. In this section we modified this algorithm for improve the quality of reconstructed images. The main steps of this modification are:

1.For an M × M image, the image is first partitioned into fixed size square blocks, each block of size n × n.

2.Then, for each partition block,

a. Determine the mean value.

b. Divide each element in the block on the mean value.

3. Form an initial codebook by choosing the first N-input image vectors as reproduction vectors.

4.Compare each input vector with all N-reproduction vectors. Best match is achieved when the minimum mean square error (MSE) between the reproduction and the input vectors is within a pre-specified threshold. In this case the input matched vectors should be given the same index of the reproduction vector.

5. For each index, find the centriod of all input vectors. The centriods are the new codebook.

6. Sort the codebook vectors in descending order from high count to low count.

7.Eliminate the last reproduction vector, which has very low count and split the first reproduction vector (i.e., high count) into two vectors by multiplying the vector contents by enlargement/reduction factors (say, 1.1/0.9) to reproduce two new vectors.

8. The procedure repeats until the process converges to solution, which is a minimum of the total reproduction error. In this work, we found that acceptable RGB image may be fulfilled after two iterations

This algorithm applied separately on luminance component (Y) and both chrominance components (I and Q) of the Ant Nebula colored image, which has 24b/p, and its size is 256x256 pixel (see figure1).The experimental results from implementing MVQ algorithm are listed in Table (1) for block sizes 4x4 and 8x8. Figure (2) display the reconstructed RGB images. The results indicated that this method allows for increasing the block size (i.e.,8×8) while preserving the quality of image to in acceptable level, and the compression ratio be high, but the reconstructed RGB image suffers from edge degradation.

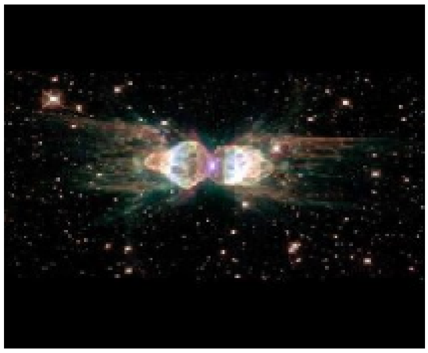
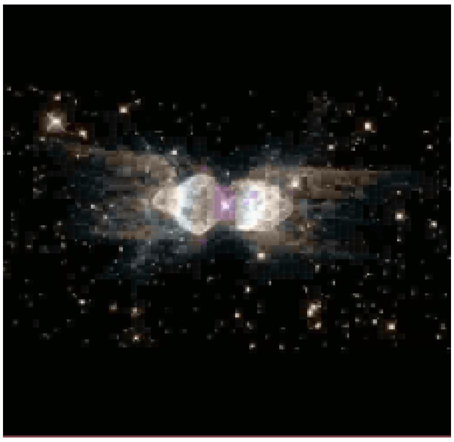


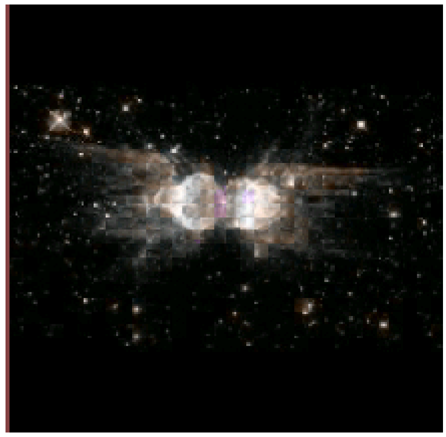
Fig. (1) The original Ant Nebula colored image

Table (1): Compression efficiency parameters produced from applying MVQ method for different block sizes

Block size	***Codebook size of I component=8 Codebook size of Q component=4 Bits(Y)=8 ,Bits(I)=5 ,Bits(Q)=2***		
	Codebook size of Y component	***C.R***	***PSNR (dB)***
4x4	**256**	**16.366**	**31.901**
	128	**17.568**	**30.305**
	64	**19.033**	**28.422**
	32	**20.811**	**27.268**
	16	**23.181**	**24.668**
	8	**26.828**	**22.597**
8x8	**256**	**37.715**	**30.895**
	128	**38.864**	**25.121**
	64	**40.950**	**24.181**
	32	**44.587**	**23.078**
	16	**50.682**	**22.545**
	8	**60.841**	**22.346**



Codebook Size of Y component = 256
C.R. = 16.366
PSNR = 31.901
Block Size= 4x4



Codebook Size of Y component = 256
C.R. = 37.715
PSNR = 30.895
Block Size=8x8

Fig. (2): The reconstructed RGB images from applying MVQ method

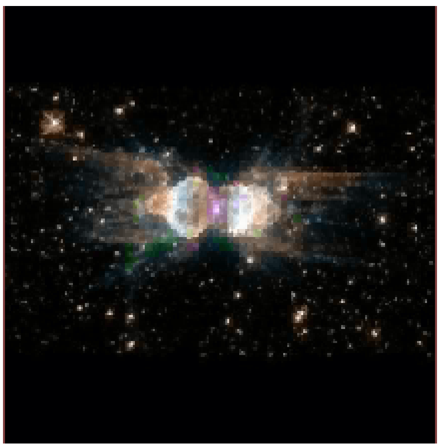
V.The MBTC-MVQ Method

Almost all edges in the decoding images using MVQ are of jagged appearance. MBTC attempts to preserve the edge pattern ,however , the reconstructed edges have a tendency to be ragged due to the inherent quantization noise in the four-levels quantizer. In this section, a new method that combines the advantage of both MVQ and MBTC to combat the edge degradation is presented and will be referred to as MBTC-MVQ. In this method, the input image is partitioned into non overlapping n x n blocks, then on each block MBTC is applied as described in section II (in the present work we used four quantization levels), and finally the MVQ technique which described in section III is implemented on the bit-map blocks, which produced from applying MBTC, thereby, drastically reducing the MVQ coding complexity. This procedure applied on the luminance component, while for both chrominance components only a single value (i.e. the mean) was used to encode each block instead of (four quantization levels) because most of image energy is distributed in luminance component then MVQ is implemented. It is very imported to mention here that for each block the mean value, four quantization levels, the index of the reproduction vector, and codebook size should be transmitted to the decoder. Table (2) presents the compression parameters obtained by applying MBTC-MVQ method while Figure (3) presents the reconstructed RGB images.

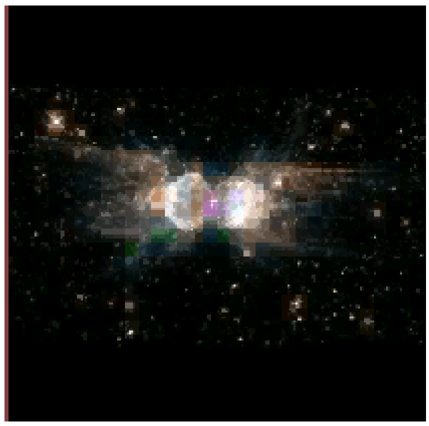
Table (2): Compression efficiency parameters produced from applying

MBTC-MVQ method for different block size.

Block size	Codebook size of I component=8 Codebook size of Q component=4 Bits(Y)=8 ,Bits(I)=5 ,Bits(Q)=2		
	Codebook size of Y component	C.R	PSNR (dB)
4x4	256	17.743	31.841
	128	18.454	31.670
	64	18.928	30.976
	32	19.207	30.576
	16	19.359	29.845
	8	19.439	29.678
8x8	256	*59.90*	*29.131*
	128	*62.444*	*27.694*
	64	*65.830*	*26.984*
	32	*69.477*	*26.078*
	16	*72.602*	*25.803*
	8	*74.799*	*25.499*



Codebook Size of Y component = 256
C.R= 17.743
PSNR=31.841
Block Size=4x4



Codebook Size of Y component = 256
C.R= 59.90
PSNR=29.131
Block Size=8x8

Fig. (3) The reconstructed RGB images from applying MBTC-MVQ

V. Conclusions

From the results presented in this study. Some of the important conclusions can be presented as follow:

1- MVQ method provides high-compression ratios, fast codebook based decoding and good subjective performance, but the encoding procedure is quite time consuming.

2-Almost all edges in the reconstructed images using MVQ method are of jagged appearance

3- MBTC-MVQ method combines the advantage of both MVQ and MBTC to combat the edge degradation.

4-MBTC-MAVQ method provides improved edge reconstruction and good performances of compression ratio about (59:1).

5- The results from applying MBTC-MVQ method indicated that the reconstructed images quality is highly affected by utilizing the size of the codebook, i.e., as the number of code words within the codebook is increased, the reconstructed RGB images distortion will be decreased. On the other hand, we utilized very small size of codebook for both chrominance components comparing with codebook size of luminance component because most of the image energy is distributed in luminance component and to maintain a relatively high fidelity coding of luminance to satisfy the human visual system.

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ضغط الصور الفلكية الملونة باستخدام تقنية بتر المقاطع متعددة المستويات والتكميم ألاتجاهي المعدلة

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الخلاصة

ان الطريقة العامة لضغط الصور الملونة تبدأ بتحويلها من نظام RGB الى إحدى الأنظمة اللونية المناسبة ومن ثم تطبيق إحدى تقنيات ضغط الصور على هذه الأنظمة الجديدة، ثم يتم إعادتها إلى النظام السابق RGB .

في هذا البحث تم اقتراح طريقة ضغط الصور الملونة اعتمدت على تقنية بتر المقاطع متعددة المستويات وطريقة التكميم ألاتجاهي. ومن خلال استثمار سلوكية استجابة المنظومة البصرية لعين الإنسان للألوان فقد تم اقتراح وتنفيذ طريقة لتوزيع الثنائيات خلال عملية التشفير بطريقة أكثر كفاءة مما أدى ذلك إلى زيادة نسبة الضغط بشكل ملحوظ.ولغرض تحسين كفاءة إنجاز طريقة التكميم الاتجاهي تم إجراء بعض التعديلات عليها. وللجمع بين خواص طريقة بتر المقاطع متعددة المستويات ذو الحسابات البسيطة وحفظ حافات الصور المسترجعة مع خواص طريقة التكميم ألاتجاهي المعدلة وهي نسبة الضغط العالية وكفاءة انجاز عيانية جيدة تم استخدام طريقة جديدة تربط بين هاتين الطريقتين لمحاربة تردي الحافات الناتجة من طريقة التكميم ألاتجاهي المعدلة.لقد أظهرت نتائج التحليل ان لهذه الطريقة كفاءة أنجاز جيدة حيث كانت الصور المسترجعة ذات مستوى تشويه اقل مع نسبة ضغط عالية(59:1).