IMPROVED IMAGE COMPRESSION BASED WAVELET TRANSFORM AND THRESHOLD ENTROPY

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ABSTRACT

In this paper, a method is proposed to increase the compression ratio for the color images by dividing the image into non-overlapping blocks and applying different compression ratio for these blocks depending on the importance information of the block. In the region that contain important information the compression ratio is reduced to prevent loss of the information, while in the smoothness region which has not important information, high compression ratio is used .The proposed method shows better results when compared with classical methods(wavelet and DCT).

تحسين ضغط الصور بالاعتماد على محول المويجة وعتبة الانتروبي

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الخلاصة

في هذا البحث، تم أقتراح طريقة لزيادة نسبة الضغط للصور الملونة عن طريق تقسيم الصورة الى كتل غير متداخلة وتطبيق نسب ضغط مختلفة إلى هذه الكتل بالاعتماد على المعلومات المهمة في هذه الكتل. في المنطقة التي تحتوي على معلومات هامة يتم تخفيض نسبة الضغط لمنع فقدان المعلومات، بينما في المنطقة الناعمة(خالية من الترددات العالية) التي لم يتم استخدام معلومات هامة نسبة الضغط عالية. الطريقة المقترحة تظهر نتائج أفضل بالمقارنة مع الطريقة الكلاسيكية (wavelet and DCT).

INTRODUCTION

Image compression is the process of encoding information using fewer bits (or other information-bearing units) than an un-encoded representation would use through use of specific encoding schemes. Compression is useful because it helps to reduce the consumption of expensive resources, such as hard disk space or transmission bandwidth (computing) [Baluram, MHD.Farukh,and Pradeep Dhakad 2011]. These methods reduce the space necessary to store or transmit the image data by changing the way these images are represented. There are numerous methods for compressing digital image data and each has its own advantages and disadvantages [K.Somasundaram and I.K. Raj 2006].

One of the most commonly used lossy compression methods is that of transform coding using one of the many image transforms available [Panagiotacopulos,K. Friesen and S. Lertsuntivit 2000]. Recent years, many studies have been made on wavelets. An excellent overview of what wavelets have brought to the fields as diverse as biomedical applications, wireless communications, computer graphics or turbulence, is given in Image compression is one of the most visible applications of wavelets. A typical still image contains a large amount of spatial redundancy in plain areas where adjacent picture elements (pixels) have almost the same values. It means that the pixel values are highly correlated[S.Grgic, M.Grgic., and B. Zovko-Cihlar 2001].

During the past few decades , several kinds of transforms have successively been developed for image compression, such as the Karhunen–Loève transform(KLT) , discrete cosine transform (DCT) , and discrete wavelet transform(DWT)[Bo Li, Rui Yang, and Hongxu Jiang 2011] . The blocking artifacts and mosquito noise are absent in a wavelet-based coder due to the overlapping basis functions[Mandal, S. Panchanathan and T. Aboulnasr 1995].The redundancy (both statistical and subjective) can be removed to achieve compression of the image data. The basic measure for the performance of a compression algorithm is compression ratio (CR), defined as a ratio between original data size and compressed data size. In a lossy compression scheme, the image compression algorithm should achieve a tradeoff between compression ratio and image quality. Higher compression ratios will produce lower image quality and vice versa. Quality and compression can also vary according to input image characteristics and contents. Transform coding is a widely used method of compressing image information. In a transform-based compression system two-dimensional (2-D) images are transformed from the spatial domain to the frequency domain. An effective transform will concentrate useful information into a few of the low-frequency transform coefficients [S.Grgic, M.Grgic., and B. Zovko-Cihlar 2001].

PREPROCESS

The main purpose of the apply preprocess is to generate the wavelet transform blocks from the raw image data. One possible optimization, in order to achieve better compression ratio, is to apply color spaces transform. The proposed method takes advantage of the fact that small color changes are perceived less accurately than small changes in brightness. The human eyes are much more sensitive to brightness variations than to hue variations [H.Gu, D. Hong, and M. Barrett 2003].

Therefore, the hue data can be compressed more heavily than the brightness data[K. R. Castleman 1996]. RGB is a way that a computer defines a color in terms of the extensions of red, green, and blue components on CRT. YCbCr color space [R.Steinmetz and K. Nahrstedt 1997] was used internally in the MinImage. The following are the RGB to YCbCr and YCbCr to RGB conversion equations[R.Steinmetz and K. Nahrstedt 1997].

$Y = 0.2989R + 0.5866G + 0.1145B$

$Cb = -0.1688R - 0.3312G + 0.5B$

$Cr = 0.5R - 0.4184G - 0.0816B$ (1)

$R = Y + 1.4022Cr$

$G = Y - 0.3456Cb \_ 0.7145Cr$

B = Y + 1.7710Cb   (2)

The color space transform is necessary for compressing the true color images since the Y space contains more information than the Cb and the Cr spaces. Thus, the compressor can treat these color spaces differently in order to get greater compression ratio. By comparing the three color spaces, the Cb and Cr color spaces are easier to be compressed than the Y color space. The Cb and Cr color spaces contain less important information [H.Gu, D. Hong, and M. Barrett 2003].

PROPOSED METHOD

In the proposed method, the input image is transformed and then truncated according to a given threshold. The basic steps for implementing this procedure are outlined in the following steps:

Step 1: Load the image

Step 2: Applying color transformation, by converting the image from RGB into y CbCr.

Step 3: Each component in the image(y ,Cb ,and Cr) is subdivided into non-overlapping Mx M blocks.

Step 4: The 2D wavelet transform is applied to each block of the image.

Step 5: Compute the combination entropy (**CE**) of the current block according to the following equation [A. Tinku,., and K.Ajoy 2005]:

$$C.E = - \sum_n P_n \log_2(P_n), bit/block \qquad (3)$$

Where, p_n is the combination probability of the nth pixel in i^{th} block. The larger combination entropy of an image mean richer information and low redundancy in the current block .The value of threshold is small to keep this important information .A lower combination entropy means fewer information and high redundancy in the current block .Therefore the value of a threshold is big because the information of this block has few coefficient. The wavelet transformation coefficients are truncated such that all the coefficients whose values are less than a given threshold (**TH**) are set to zero. The threshold takes percentage of the minimum and maximum coefficient values throughout the whole block coefficients. Threshold of current block is based on its entropy. There are two types of threshold operator called threshold transform, $T(.,\lambda)$ associated with the threshold λ, the hard threshold operator $T_h(.,\lambda)$ and the soft threshold operator $T_s(.,\lambda)$.

The hard threshold operator is defined as[C. Perrin, B. Walczak, and D. s. Massart 2001]:

$$S = T_h(Y_W, \lambda) = \begin{cases} Y_W & \text{if } |Y_W| \geq \lambda \\ 0 & \text{otherwise} \end{cases} \qquad (4)$$

The soft threshold operator is defined as [A. Tinku,., and K.Ajoy 2005]:

$$S = T_s(Y_W, \lambda) = \begin{cases} sign(Y_W)(|Y_W| - \lambda) & \text{if } |Y_W| > \lambda \\ 0 & \text{otherwise} \end{cases}$$

$$(5)$$

Where, Y_W is the transform coefficient, and S are the threshold coefficients obtained after applying the threshold operator $T(.,\lambda)$. The transfer functions of the hard and soft threshold schemes are shown in Fig .1. Note that, hard threshold is a "keep or set to zero" procedure and is more intuitively appealing. On the other hand, soft threshold shrinks coefficients above the threshold in absolute value. While at first sight hard threshold may seem to be natural, the continuity of soft threshold has some advantages. In this paper the hard threshold is used and   the type of threshold is quintile. In this method a percentage ratio of entries to be eliminated are selected. The smallest (in absolute value) ratio percent of entries are set to zero.

Step 6: Finally, quantization of each blocks in the image.
By applying a 2D inverse wavelet transform on compressed image, the decompressed image (reconstructed) will be obtained. The additive white Gaussian noise is added to image. Fig. 2 shows the proposed method flowcharts.
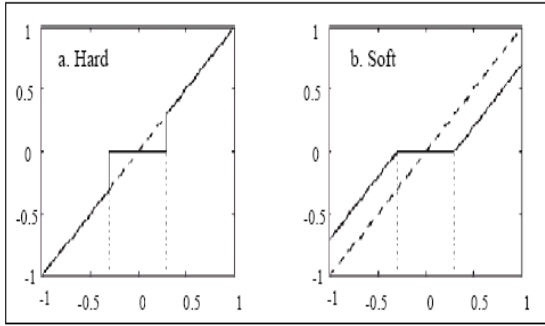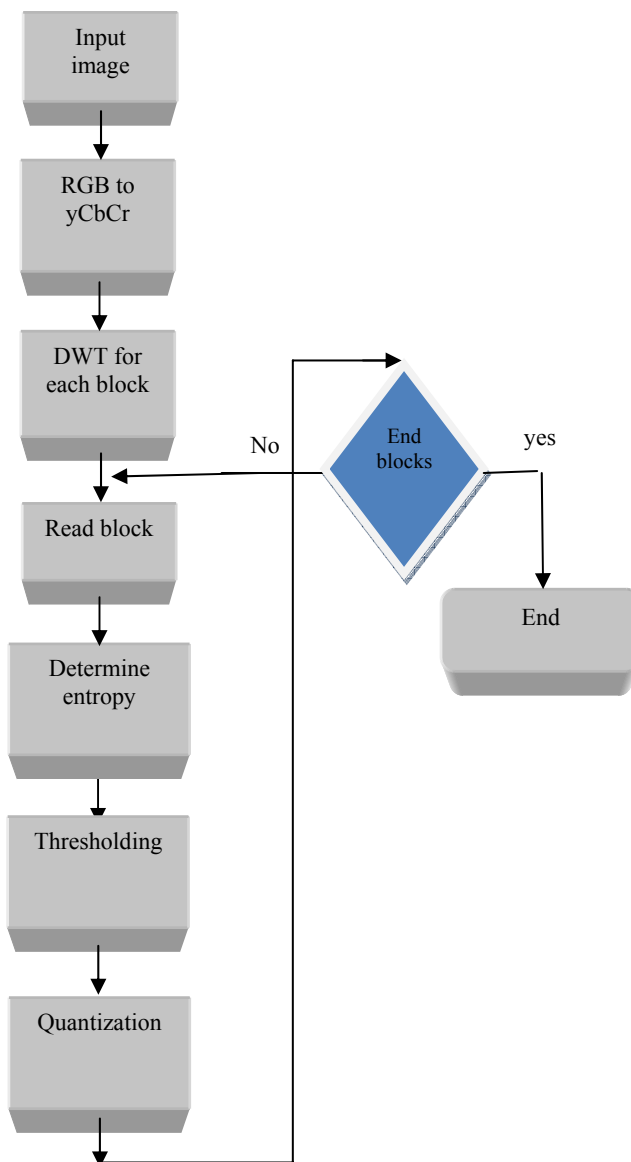
Figure1 Threshold (Shrinkage) functions

Figure 2   Proposed algorithm flowcharts

SIMULATION RESULTS

The proposed model is tested for compressing some images. The proposed method is realized using Matlab 7 R2010a package, with different test images of size 256*256 pixels as shown in the Fig.3. The proposed method was compared with standard DCT and wavelet methods.

Table 1 shows different compression ratio (92%,95%,97%)and the   PSNR in dB obtained using the proposed method and wavelet and DCT based compression for different color images. Fig. 4 shows the reconstructed (decompressed) images based different methods. The peak signal to noise ratio, is defined as[K. S. Thyagarajan 2006] below:

$$PSNR = 10\log\left\{\frac{(255)^2}{\frac{1}{N}\sum_{r=0}^{N-1}\sum_{c=0}^{N-1}[\hat{I}(r,c)-I(r,c)]^2}\right\}$$

(6)

Where I(r,c) represents original image and Î(r,c) represents decompressed image[K. S. Thyagarajan 2006].

The most popular metric of performance measure of a data compression algorithm is the compression ratio. It is defined as the ratio of the number of bits to represent the original data to the number of bits to represent the compressed data.

The compression performance of the new approach is assessed through computer simulation. Considering various compression parameters such as the percentage of compression ratio and the PSNR in decibels of different images, it is, in general, observed that the accuracy of the reconstruction of the proposed method gives good results as compared with the other methods. Exhaustive computer simulation results on different images indicate this trend.

Table 1:PSNR in dB obtained using different compression ratios for different images.

Image	Method	compression 92%	compression 95%	compression 97%
1	Proposed Method	25.8 dB	24.90 dB	23.12 dB
	Classical Method (Wavelet)	23.8 dB	22 dB	20.4dB
	Classical Method (DCT)	23.2db	21.4 dB	18.3 dB
2	Proposed Method	31.3 dB	29.4 dB	27.6 dB
	Classical Method (Wavelet)	28.2 dB	26.4 dB	23 dB
	Classical Method (DCT)	25.2 dB	24.1d B	20 d B

CONCLUSION:

This paper presents image compression technique. Instead of compressing all image with one compression ratio by selecting one threshold value for all pixels of the image, A threshold value is determined for each block in the image after dividing the image into M*M blocks .therefore getting different threshold values.

Based on the simulation results obtained in this study, the proposed approach can achieve high-compression ratio with high SNR. According to the results in **Table 1**, the obtained subjective tests show the superiority of the proposed algorithm when compared to the classical approaches. An important advantage of this method appears at edge region, because the proposed method keep the information at these region by reducing the compression ratio by selecting low threshold value.

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Figure 3 Testing images

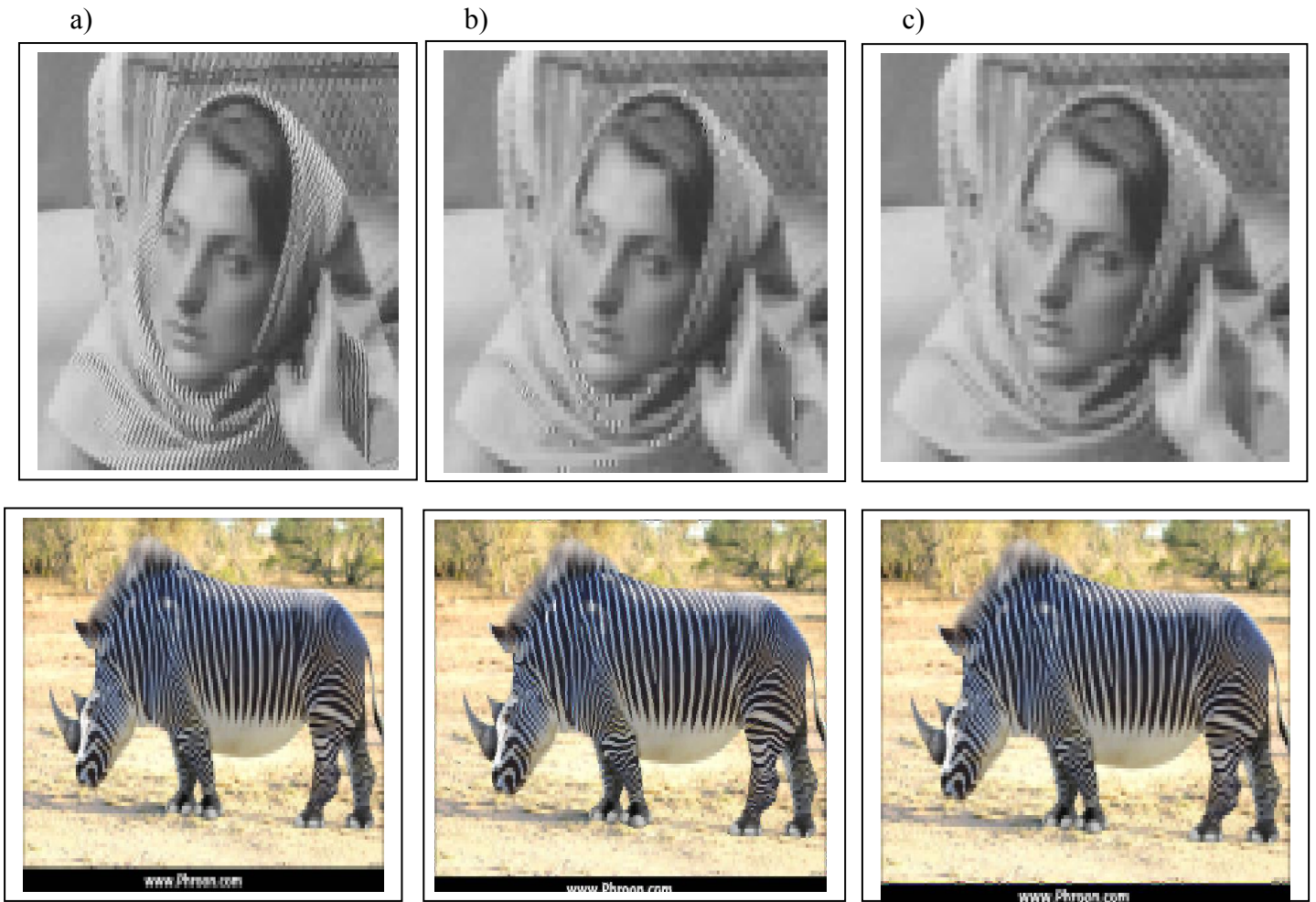a)   b)   c)

Figure 4   Reconstructed Images. a) Proposed method. B) Wavelet. C) DCT Method.