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AN EFFICIENT REARRANGEMENT OF DATA FOR GRAY IMAGE COMPRESSION BASED ON WAVELET TRANSFORM

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ABSTRACT :- In this paper a new method is a proposed for gray image compression based on re-ordering the data of image before applying a wavelet transform. The advantage of converting the color image into luminance-chrominance color space is that the luminance and chrominance components are very much decorrelated between each other. Moreover, the chrominance signals contain much redundant information and can easily be subsampled without sacrificing any visual quality for the reconstructed image

In this paper a rearrangement of the gray image data is done by dividing it into three components (similar the RGB components of the color image) and convert color space from RGB to YC_bC_r (Y: luminance, C_b chrominance/blue, and C_r is chrominance/red) then apply wavelet transform. This method can return information more than wavelet method therefore very good result and high PSNR are obtained when it is compared with wavelet transform.
Keywords: Discrete wavelet transform (DWT), Gray image, YCbCr.

1. INTRODUCTION

With the increasing demand of manipulation, storage, and transmission of digital images, great efforts are made to seek image compression algorithms, which are of modest complexity, exhibit efficient compression performance, and can provide scalability. There are various compression techniques such as entropy coding, prediction coding,transform coding etc. Transform coding is a favorite one among those, because of its basal precondition that most of the energy of the image could be compressed on two or three transformed subbands. [1].Many image processing tasks take advantage of sparse representations of image data where maximum information is packed into a small number of samples. Typically, these representations are achieved via non-redundant and invertible transforms. Currently, the most popular choice for this purpose is wavelet transform [2]. A compression technique involves a transform to extract for feature information contained in the data and a logic for removal of redundancy present in the extracted features. The discrete cosine transform (DCT) is conventionally used for data compression because of its orthogonal property[3] .In the recent past the discrete wavelet transform (DWT) has emerged as a potential tool for analysis, denoising [4] and compression of different signals because it provides relatively efficient representation of piecewise smooth signals[5] .

2. COLOR IMAGES

Color perception is a sensation produced when light excites the receptors in the human retina. Color can be described by specifying the light's spectral power distribution. Such a description is highly redundant because the human retina has only three types of receptors that influence color [6].In a typical color image, the spatial intercomponent correlation among the red, green, and blue color components is significant. In order to achieve good compression performance, correlation among the color components is first reduced by converting the RGB image into a decorrelated color space [7].The color space conversion modules transforms Red Green Blue (RGB) encoded data into YC_bC_r coding. Y represents luminance (based on inverse gamma-distorted data) and C_bC_r represents chrominance[8].The advantage of converting the image into luminance-chrominance color space is that the luminance and chrominance components are very much decorrelated between each other. However, if the RGB image is composed of mostly one color, then the YC_bC_r representation cannot improve on the efficient energy compaction in RGB. For these color images, RGB compression quality is superior to YC_bC_r compression quality [9].The transformation from RGB to YC_bC_r, is done based on the following mathematical expression [10].

$$\begin{pmatrix} Y \\ C_b \\ C_r \end{pmatrix} = \begin{pmatrix} 0.299000 & 0.587000 & 0.114000 \\ -0.168736 & -0.331264 & 0.500002 \\ 0.5 & -0.418688 & -0.081312 \end{pmatrix} \begin{pmatrix} R \\ G \\ B \end{pmatrix} + \begin{pmatrix} 0 \\ 128 \\ 128 \end{pmatrix} \quad ...(1)$$

The corresponding inverse relationship is given by [10].

$$\begin{pmatrix} R \\ G \\ B \end{pmatrix} = \begin{pmatrix} 1 & 0 & 1.40210 \\ 1 & -0.34414 & -0.71414 \\ 1 & 1.77180 & 0 \end{pmatrix} \begin{pmatrix} Y \\ C_b \\ C_r \end{pmatrix} - \begin{pmatrix} 0 \\ 128 \\ 128 \end{pmatrix} \quad \dots (2)$$

From eq (2) we note that C_r=red component – luminance component
And Cb=blue component – luminance component.

3. DISCRETE WAVELET TRANSFORM (DWT)

Wavelet analysis has become a powerful tool for image and signal processing .Initially developed for approximations and analysis of functions of a single real variable, wavelet techniques were almost immediately generalized for the case of two and many variables [11].Wavelets and filter banks have become useful in digital signal processing in part because of their ability to represent piecewise smooth signals with relative efficiency. For such signals, the discrete wavelet transform (DWT) of an n-point vector is again an n-point vector, but one for which the energy is compacted into fewer values. In as far as this is true, the DWT is useful for signal compression, fast algorithms, and signal estimation and modeling (noise suppression and image segmentation, etc). The DWT is usually implemented as an iterated digital filter bank tree, so the design of a wavelet transform amounts to the design of a filter bank [12].In a nutshell, the DWT replaces the infinitely oscillating sinusoidal basis functions of the Fourier transform with a set of locally oscillating basis functions called wavelets. In the classical setting, the wavelets are stretched and shifted versions of a fundamental, real-valued bandpass wavelet $\psi(t)$. When carefully chosen and combined with shifts of a real-valued low-pass scaling function $\varphi(t)$, they form an orthonormal basis expansion for one-dimensional (1-D) real-valued continuous-time signals . That is, any finite energy analog signal $x(t)$ can be decomposed in terms of wavelets and scaling functions[13].

4. PROPOSED ALGORITHM

4.1 COMPRESSION STEPS

The steps of a proposed method which is based on the color transformation are (shown in figure 1):

First

Treat the gray image as the color image by subdividing the gray image into three components similar to RGB components of the color image, and by considering each three pixels in a gray image as the colors Red, Green, Blue for one pixel. After this rearrangement, three components are obtained.

Second

Applying RGB to YCbCr conversion. After the color space conversion, most of the spatial information of the image is contained in the luminance component (Y) [10].

The chrominance components (Cb and Cr) contain mostly redundant color information and very little information will be lost by subsampling these components both horizontally and/or vertically [10]. The subsample process is simply throwing away every other sample in each row and/or in each column if desired.

Third

Applying wavelet transform on the luminance and resulting chrominance (Cb and Cr) components.

Fourth

The Multiwavelet coefficients whose magnitude values are less than a prespecified value called (Threshold value) are set zero (discarding). So that the transformed image after thresholding will contain long strings of zeros. The value of threshold(usually equal to 70%-80% of total energy of the image)is based on nature of image and the transform used. The threshold value affects the compression ratio; therefore several thresholds value will be tested until achieve the desired compression ratio.

Fifth

After thresholding , all coefficients are quantized. Quantization is the process by which the coefficients are reduced in precision (simplest quantization is the nearest integer, i.e. 4.3 becomes 4).

This operation is lossy(because this process leads to reduction in bit per pixel), unless coefficients are integers .The following figure shows the compression stage.

4.2 DECOMPRESSION STEPS

The stages of image decoder are shown in Figure 2. To get the reconstructed image, the inverse wavelet transform is applied on compressed image. Then transform the resulted image from YCbCr component to RGB component according to eq.2 .Finally RGB component of a gray image are obtained.

5. SIMULATION RESULTS

In this section, the implementation results and the performance of the proposed algorithm when compared with the wavelet approach are presented. The proposed algorithm is implemented using Matlab package with test images with size 256*256 pixels(8bit/pixel).

The comparison is measured by the compression ratio (CR) and Peak to Signal Ratio (PSNR), i.e. the quality of reconstructing the original image (measured in term of PSNR). Compression ratio is the most popular metric of performance measure of a data compression algorithm. 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 and defined as[7]

CR = (1 - (Compressed Image Size/Original Image Size)) x 100. …. (3)

while PSNR is defined as[7]

$$SNR_{PEAK} = 10 \log \left(\frac{(255)^2}{\frac{1}{N} \sum_{r=0}^{N-1} \sum_{c=0}^{N-1} \left[\hat{I}(r,c) - I(r,c) \right]^2} \right) \quad \text{….(4)}$$

where N represent the size of the image

$I(\gamma,c)$ original image

$\hat{I}(\gamma,c)$ reconstructed image

Table(1) shows the difference between the proposed model and wavelet transform. The results obtained in table 1 obtained after applying proposed method and standard method (wavelet transform) with different threshold values until achieve the same compression ratio for each image.

Clearly that the proposed model achieves the best performance, as expected from the continuous theory.

6. CONCLUSION

In this paper, the proposed model has been applied for compression of image. The compression performance of the new approach is assessed through computer simulation and the results are compared with the DWT approaches. The edge in the proposed model is kept because there are three components having the similar information. This leads to the PSNR of the proposed model higher than wavelet method. Considering various compression parameters such as the percentage of compression ratio and the PSNR in decibels of different image, it is, in general, observed that the accuracy of the reconstruction of the proposed method is better than that of wavelet method. Exhaustive computer simulation results on different image signals indicate this trend. Thus it is, in general, concluded that the proposed model based compression technique yields better performance compared to the DWT.

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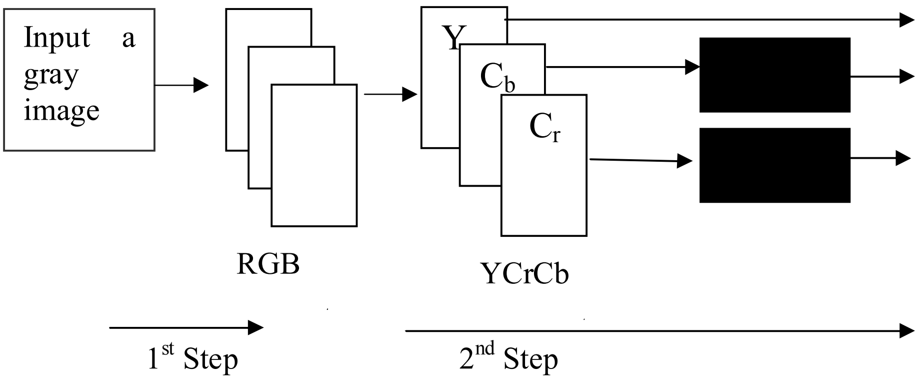
Image (1)

Image (2)

Image (3)



(a)

(b)

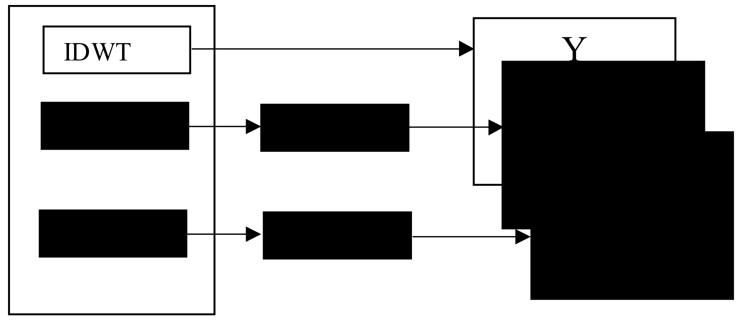


Fig. (1): Image Encoder (a) 1st and 2nd Steps. (b) 3rd, 4th, and 5th Steps .

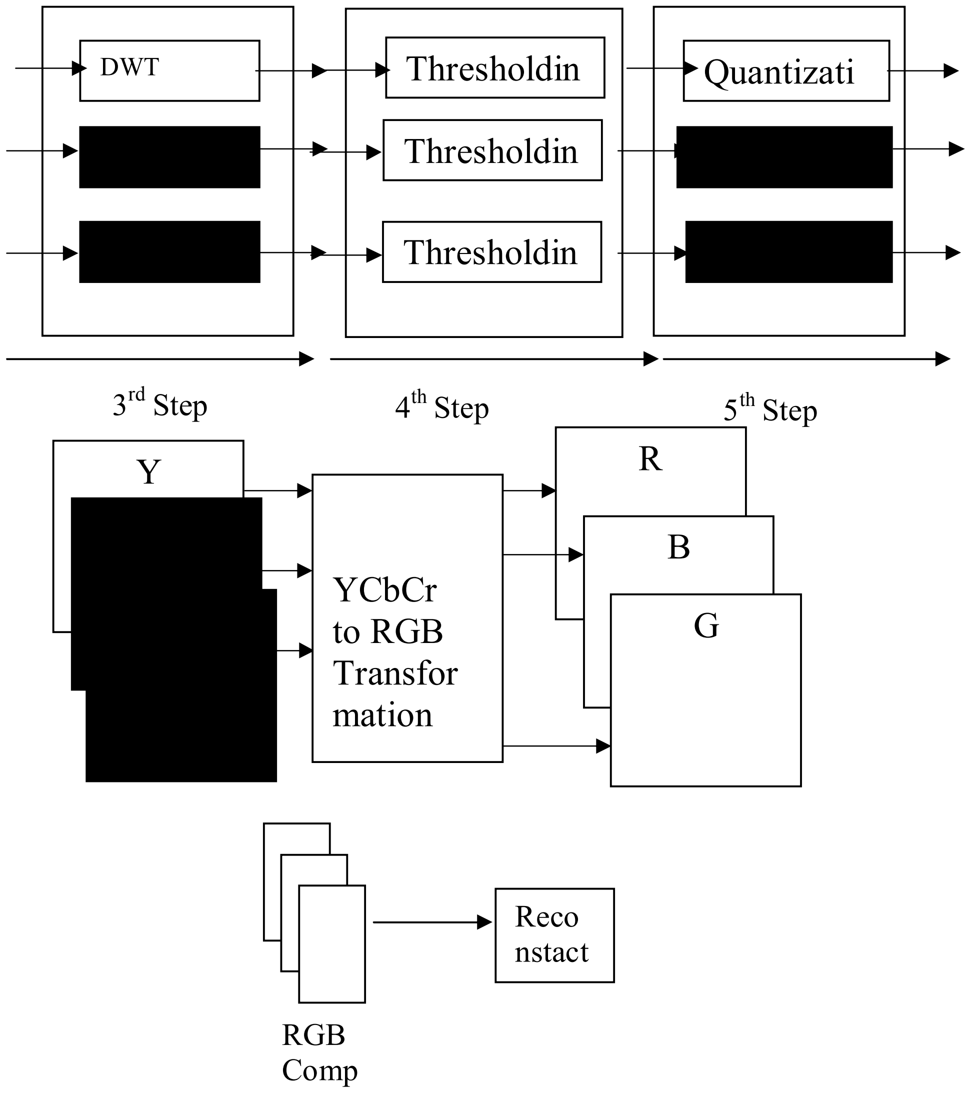
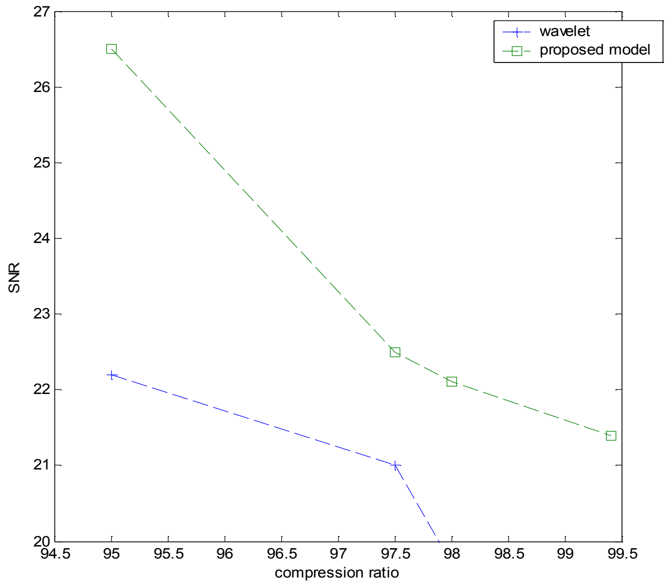


Fig.(2): Image decoder.

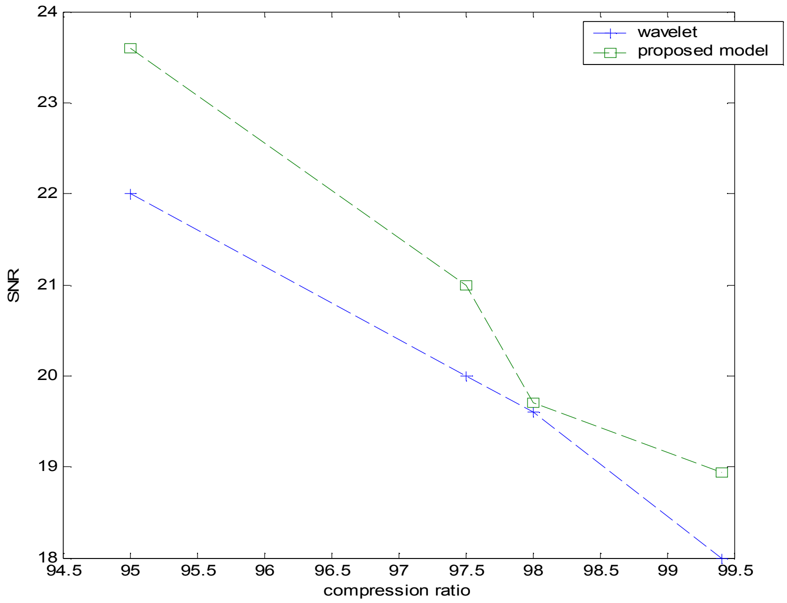
Table(1): Compression ratio and the PSNR in dB obtained using the proposed model and wavelet based compression for different image .

Image	method	CR 95%	CR 98.7%	CR 99.1%	CR 99.4%
1	wavelet	26.09 dB	24.09 dB	23 dB	22.21 dB
	Proposed	29.61dB	25.28 dB	24.77 dB	24.11 dB
2	wavelet	20.8 dB	19.6 dB	17.4 dB	16.73 dB
	Proposed	23.6 dB	20.6 dB	19.6 dB	18.94 dB
3	wavelet	22.2 dB	21 dB	19.7 dB	18 dB
	Proposed	26.5 dB	22.5 dB	22.1 dB	21.4 dB

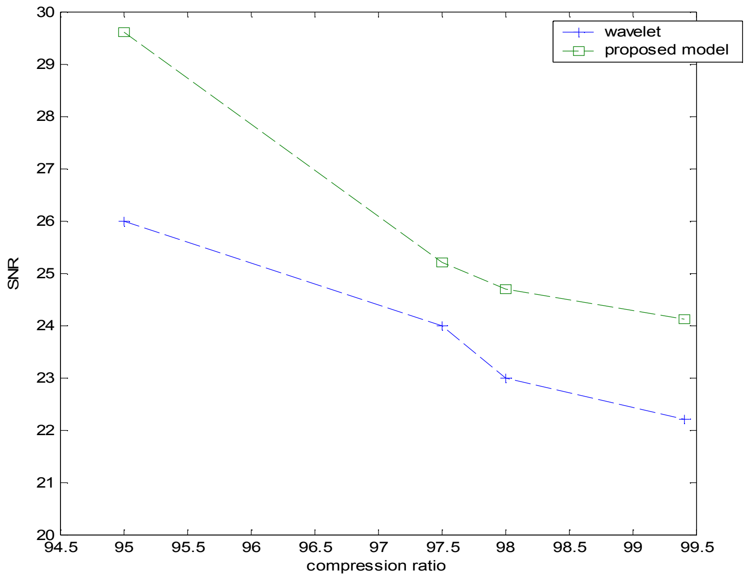
Fig.(3-5) :Show in more details the difference between the proposed method and the wavelet.



(Fig. 3): Compression ratio vs. PSNR for Image 1



(Fig. 4): Compression ratio vs. PSNR for Image 2.



(Fig. 5) : Compression ratio vs. PSNR for Image 3.

أعادة ترتيب البيانات بصورة كفؤة للصور المضغوطة بالاعتماد على التحويلات التموجية

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الخلاصة

في هذا البحث تم اقتراح طريقة جديدة لضغط الصور تعتمد على إعادة ترتيب بيانات الصورة قبل تطبيق تحويل المويجة بحيث نحصل على نتائج أفضل. حيث سنعتمد على ميزة تستخدم دائما في الصور الملونة وهي تحويل ألالوان من RGB إلى YCbCr. إن فائدة التحويل الى luminance-chrominance هو إن هذه المركبات لأن تمتلك تشابه فيما بينها. إضافة إلى ذلك فان معلومات ال(chrominance) يمكن تقليلها ويمكن اخذ جزء منها بدون ضياع ملحوظ في البيانات. في هذا البحث تم تقسيم الصورة العادية الى ثلاث مركبات شبيهة بمركبات الصور الملونة وطبق تحويل الالوان قبل نطبق تحويل المويجة. في هذه الطريقة يتم إرجاع معلومات أفضل من تحويل المويجة لذلك كانت النتائج أفضل و ال(PSNR) أعلى عند مقارنة الطريقة المقترحة بطريقة تحويل المويجة .