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New Efficient Method for Coding Color Images

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Abstract: In this paper a novel color image compression technique for efficient storage and delivery of data is proposed. The proposed compression technique started by RGB to YCbCr color transformation process. Secondly, the canny edge detection is used to classify the blocks into edge and non-edge block. Each color component Y, Cb, and Cr compressed by discrete cosine transform (DCT) process, quantizing and coding step by step using adaptive arithmetic coding. Our technique is concerned with the compression ratio, bits per pixel and peak signal to noise ratio, and produc better results than JPEG and more recent published schemes (like, CBDCT-CABS and MHC). The provided experimental results illustrate the proposed technique is efficient and feasible in terms of compression ratio, bits per pixel and peak signal to noise ratio.

Keywords: Image compression, Color image, Q-coder, Quantization, Edge-Detection, DCT transform, image coding.

1 Introduction

In the recent years there has been an astronomical increase in the usage of computers for a variety of tasks. One of the most common usage has been the storage, manipulation, and transfer of digital images. The files that comprise these images, however, can be quite large and can quickly take up precious memory space on the computer's hard drive. In multimedia application, most of the images are in color. Color images contain lot of data redundancy and require a large amount of storage space. Image compression refers to the reduction of the size of the data that images contain. Generally, image compression schemes in [1,2,3] exploit certain data redundancies to convert the image to a smaller form. A typical image compression system is shown in Figure 1. The data reduction, or compression, is performed by a device known as the encoder. The encoder reduces the data size of the original image A. The compressed image B is the output which passes through a channel (usually an actual transmission channel or a storage system) to the decoder. The decoder reconstructs, or decompresses, the image C from the compressed data. The ratio of the size (amount of data or bandwidth) of the original image to the size of the compressed image is known as the compression ratio or compression rate. The compression ratio can also be expressed in bpp (bits per pixel). The term bit rate is a general term for bpp. The higher the compression rate, the greater is the reduction of data [4, 5]. Depending on the application, the channel may be affected by noise which results in distortion of the compressed image during transmission. If so, the channel is known as an error-prone channel; otherwise, it is errorless. In Figure 1, the channel is assumed to be error-free, hence B is the input to the decoder. Data compression schemes can be divided into two broad classes:

– Lossless compression schemes [6,7], in which C is identical to A.
– Lossy compression schemes [8,9], which generally provide much higher compression than lossless compression but allow C to be different from A.

This paper is structured as follows: Section 2 reviews some related work. Our technique is described in Section 3. Experimental results are shown in Section 4. Conclusions are drawn in Section 5.

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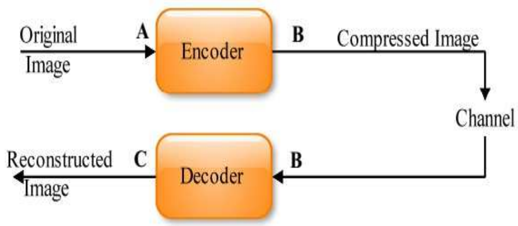

Fig. 1: Block diagram of image compression system

2 Related Work

Wang et.al [10] presented a cost effective block truncation coding (CE-BTC) using low cost approach for color image compression. The usage of line buffer memory in low cost approach CE-BTC is only a half of that in the optimal approach in CE-BTC. Therefore, the low cost approach CEBTC can be suit to apply to some resource restrained applications such as frame memory reduction in LC Displays (LCD) overdrive. Simulation results show that the proposed CE-BTC outperforms the VQ-BTC in PSNR up to 3 dB and much better subject visual quality. Sowmyan et.al [11] have been proposed several methods for color image compression but the reconstructed image had very low signal to noise ratio which made it inefficient. Their technique worked on spatial domain where the pixel values of RGB planes of the input color image is mapped onto two dimensional planes. Singh and Kumar [12] used various contemporary standards by Joint Picture Expert Group for compression. They exploited the correlation among the color components using a component color space transform before the subband transform stage. The transforms used to de-correlate the colors are primarily the fixed kernel transforms, which are not suitable for large class of images. In their paper an image dependent color space transform (ID-CCT), exploiting the inter-channel redundancy optimally and which is very much suitable for compression proposed. Also the comparative performance has been evaluated and a significant improvement has been observed, objectively as well as subjectively over other quantifiable methods.

3 The Proposed Color Image Compression Method

Each color image consists of three components whether stored in RGB or YCbCr format. For this application, the input image is first converted into YCbCr format as in [13], because in this way additional decorrelation of the components (better compression) is done. Then classified the image into background and foreground portions as describe in section 3.2. Then the image is subdivided into 8×8 blocks and DCT coefficients are computed for each block. The quantization is performed conferring to predetermined quantization table. The quantized values are then rearranged according to zig-zag scan arrangement. The less important values are discarded (as describe in section 3.3) from the list in the zig-zag arrangement. After discarding insignificant coefficients the remaining coefficients are compressed by the adaptive arithmetic coding (Q-coder).

Algorithm 1

1: Input the image to be compressed.
2: Classify the input image into background and foreground based on edges.
3: Subdivide the input image into 8×8 blocks.
4: Find the DCT coefficients for each block.
5: Quantize the DCT coefficients based on predetermined quantization table.
6: Apply the modification of the quantized coefficient based on the classification in step 2.
7: Assemble the blocks into a continuous stream.
8: Compress the resulting values by apply Q-coder.

3.1 Classification Step

Edges often occur at points where there is a large variation in the luminance values in image, and consequently they often indicate the edges, or occluding boundaries, of the object in the scene. There are several techniques have been used for edge detection [14]. In this paper, Canny Method is used. The canny edge detection algorithm is known to many as the optimal edge detector [15]. The image is divided as edge blocks and non-edge blocks.

3.2 The Modification

To increase compression ratio, in this part we suggested technique modification of JPEG compression by collection between JPEG compression technique and edge extraction. The modification will be done after the quantization step. The image is subdivided into a block of pixels and then these blocks are classified into edge (significant regions/foreground) and non-edge (insignificant regions/background) blocks. In the first method (A-1), the non-edge blocks are compressed using the DC coefficient only and all significant coefficients are used for the edge blocks. In the second method (A-2) on each component (Y, Cb and Cr), the DC coefficient only is used for coding the non-edge blocks (insignificant regions). 70(choose by experimental) of the non-zero quantized AC coefficients have been used in the coding of edge blocks. In the third method (A-3) on each component (Y, Cb and Cr), the DC coefficient only is used for coding the non-edge blocks (insignificant regions). 50coefficients have been used in the coding of edge blocks.

3.3 Q-Coder (adaptive arithmetic code)

Adaptive arithmetic code [16] is a lossless compression technique that benefits from treating multiple symbols as a single data unit but at the same time retains the incremental symbol-by-symbol coding approach of Huffman coding. Arithmetic coding separates the coding from the modeling. This process allows for the dynamic adaptation of the probability model without affecting the design of the coder. Provisions for substituting huffman coding for arithmetic coding are contained in many of the image compression standards.

4 Experimental Results

For the implementation and evaluation of the algorithms we developed a MATLAB code and performed the testing on a standard color test images Lena, Fruit and Airplane of size 512×512 and another test image Zelda and House of size 256×256 (see Figure 3). We analyze the results obtained with the first, second and finally, the proposed algorithm. All images and tables from the experiments are given. Standard measures for image compression [17,18], like compression ratio (CR) and peak signal to noise ratio (PSNR) were used, which are calculated for comparing the performance of the proposed method as per the following representations:

$$CR = \frac{Orginal\ image\ size\ in\ bytes}{Compressed\ image\ size\ in\ bytes} \quad (1)$$

$$PSNR = 10 \times log_{10} \frac{255^2 \times 3}{MSE(Y) + MSE(Cb) + MSE(Cr)} (dB) \quad (2)$$

Fig. 2: Original test images: (a) Lena, (b) Zelda, (c) Fruit, (d) House and (e) Airplane

From the results listed in Table 1, the proposed codec achieves a high performance and we can conclude that about 0.1299 - 0.3404 bit rate reduction on average is achievable by using the proposed method (A-3). The subjective visual quality is compared using different color image, as shown in Figure 3, Figure 4 and Figure 5, respectively. Figure 3 (c), Figure 4 (c) and Figure 5 (c) show less block artifact than resulted image by (A-3) with block size 8×8 in Figure 3 (a), Figure 4 (a) and Figure 5 (a). Experiment results show that (A-1) and (A-2) perform better in PSNR compared with (A-3). Although (A-1) shows a litter better performance than (A-2), the bit rate of (A-1) is much higher than that of (A-2).

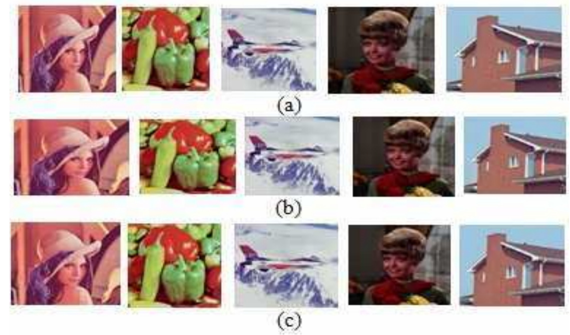

Fig. 3: Compressed images visual performance of the proposed method (A-1): (a) DCT block size is 8 × 8, (b) DCT block size is 16 × 16 and (c) DCT block size is 32 × 32

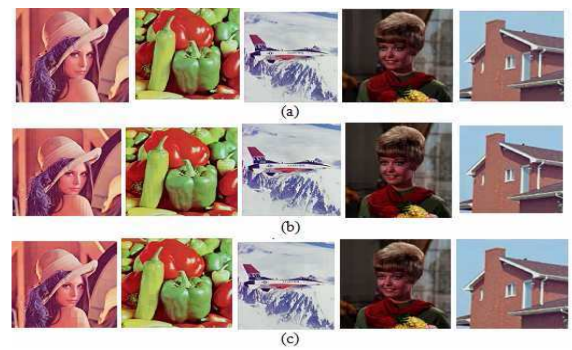

Fig. 4: Compressed images visual performance of the proposed method (A-2): (a) DCT block size is 8 × 8, (b) DCT block size is 16 × 16 and (c) DCT block size is 32 × 32

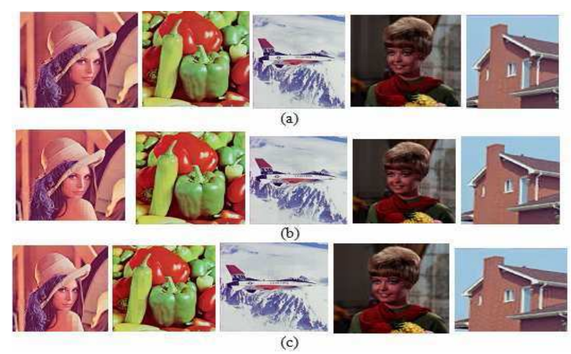

Fig. 5: Compressed images visual performance of the proposed method (A-3): (a) DCT block size is 8 × 8, (b) DCT block size is 16 × 16 and (c) DCT block size is 32 × 32

The CR results of the proposed method (A-3) and the other compared methods MHC scheme [19] are presented in Figure 6. The (A-3) obtains 35.33 on average and the best performance (41.0029) in House. Compared with CBDCT-CABS [20], the (A-3) achieves 2.8334 dB higher average performances in PSNR, especially in Airplane the improvement is up to 4.15 dB. The (A-3) also performs high better by 2.27 dB on average than the most competitive method of JPEG (as shown in Table 2).

Table 1: Performance Evaluation of the Proposed Methods

IMAGE	A-1			A-2			A-3		
	bpp	PSNR	CR	bpp	PSNR	CR	bpp	PSNR	CR
BLOCK SIZE (8×8)									
House	0.4236	35.240	56.6634	0.356	34.362	67.3430	0.322	33.938	74.5292
Zelda	0.4674	35.379	51.3504	0.374	34.580	64.0704	0.329	34.029	72.8886
Lena	0.450	34.746	53.2367	0.385	33.998	62.1937	0.351	33.544	68.2333
Airplane	0.5018	36.315	47.8289	0.392	35.198	61.2218	0.338	34.502	70.9736
Fruit	0.552	34.183	43.4682	0.456	33.739	52.5980	0.405	33.405	59.1970
Average	0.4789	35.1726	50.50952	0.3926	34.3754	61.48538	0.349	33.8836	69.16434
BLOCK SIZE (16×16)									
House	0.6631	38.3959	36.1961	0.4685	36.5021	51.2233	0.3668	35.1075	65.4270
Zelda	1.1599	37.2084	20.6910	0.7764	36.1707	30.9114	0.5732	34.9759	41.8738
Lena	0.5290	36.5823	45.3716	0.4035	35.6310	59.4734	0.3263	34.5722	73.5439
Airplane	0.7369	39.2232	32.5705	0.4938	37.1619	48.6026	0.3660	35.5585	65.5722
Fruit	0.5340	34.7061	44.9428	0.3734	34.1404	64.2661	0.2882	33.5433	83.2765
Average	0.7245	37.2231	35.9544	0.5031	35.9212	50.89536	0.3841	34.7514	65.93868
BLOCK SIZE (32×32)									
House	0.6112	38.9130	39.2656	0.4145	36.6280	57.8983	0.3122	34.9308	76.8713
Zelda	0.7188	37.1556	33.3913	0.5049	36.1446	47.5329	0.3822	35.0267	62.7915
Lena	0.6688	36.5637	35.8841	0.4561	35.5973	52.6151	0.3379	34.4493	71.0289
Airplane	0.5907	38.9460	40.6294	0.4023	36.9724	59.6556	0.2983	35.3787	80.4524
Fruit	0.3443	34.1088	69.6991	0.3133	34.1664	76.5999	0.2697	33.9348	88.9843
Average	0.5867	37.1374	43.7739	0.4182	35.9017	58.86036	0.3200	34.7440	76.02568

Table 2: Comparison Between the Proposed Method (A-3), Cbdct-Cabs [20] and JPEG Method on Test Images

IMAGE	JPEG		Proposed method (A-3)			CBDCT-CABS [20]		
	bpp	PSNR	bpp	PSNR	CR	bpp	PSNR	CR
IMAGE SIZE (256×256)								
House	1.24	31.34	0.322	33.938	74.5292	1.5305	31.667	15.681
Zelda	1.00	32.06	0.329	34.029	72.8886	1.6887	31.198	14.212
IMAGE SIZE (512×512)								
Lena	1.03	32.76	0.351	33.544	68.2333	1.6002	31.793	14.998
Airplane	0.90	31.46	0.338	34.502	70.9736	1.3374	30.349	17.945
Fruit	1.47	30.47	0.405	33.405	59.1970	1.3571	30.244	17.685
Average	1.128	31.618	0.349	33.8836	69.16434	1.50278	31.0502	16.1042

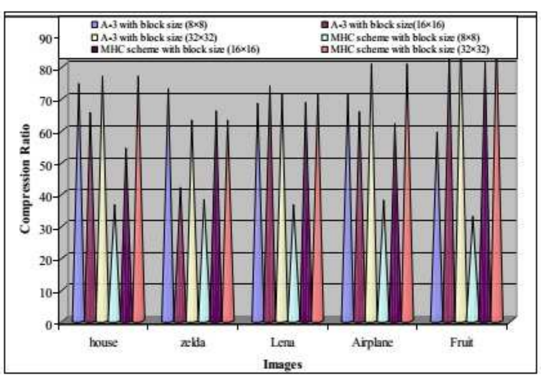

Fig. 6: Compression ratios attained for test images with different block size of the proposed method (A-3) and MHC scheme [19]

5 Conclusions

This paper analyzes the color images and identifies the most important contexts between the luminance component and the chrominance components based on the analysis, a new color image coding scheme is proposed and evaluated. Significant bit rate reduction has been achieved after employing classification step. Simulation results show that the proposed method outperforms the JPEG in PSNR up to 2.27 dB and much better subject visual quality. Comparing with CBDCT-CABS, the proposed method also performs a better in subjective visual quality and in PSNR by 2.83 dB on average. As demonstrated the best compromise results between bpp and PSNR are obtained for block size 8×8 for proposed techniques.

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