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New Approach for Color Image Compression

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***Abstract*—It is well-known that edges contain semantically important image information. In this paper, color image coding based on edge-detection is introduced. Modification of the JPEG technique to improve the color image compression is proposed. The process is based on the modification of the quantized value of the DCT coefficients. The efficiency of the proposed scheme is demonstrated by results, especially, when faced to the method presented in the recently published papers.**

***Index Terms*— Edge Detection, DCT, Image Compression and JPEG**

I. INTRODUCTION

COMPRESSION is any method reducing the original amount of data to another less quantity. One can categorize already elaborated algorithms to lossless or lossy techniques:

In the first case: the quality is totally preserved and we converse about storage or transmission reduction. In the counter part, lossy algorithms look for the check of the well-known tradeoff rate-distortion. It means that the quality of the decompressed data must be in the tolerable bounds defined by each specific application according to the maximum possible compression ratio reachable [1].

The deployment of such algorithms is evidently, of great importance. The massive exchange of large amount of different types of data (sounds, images, videosy) in Internet/Intranet or in mobile phone networks is the best example. When focusing the attention on the elaborated methods dedicated to color image lossy compression, we can enumerate: The direct methods acting by the direct processing of image samples such as those based on block truncation (BT) [2]–[4],the others techniques built around the vector quantization [5], [6]. The transform based techniques using transforms such as the DCT [7]–[9], wavelets [10]–[12] and PCA [13]. Their use is, implicitly, in order to concentrate the whole energy, contained initially in the original signal, in a few number of the transformed coefficients.

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Sadashivappa et. al. [14] tested the efficiency of color image compression using SPIHT algorithm. The SPIHT algorithm is applied for luminance (Y) and chrominance (Cb,Cr) part of RGB to YCbCr transformed image. Reconstructed image is verified using human vision and PSNR. Huffman and arithmetic coding can be added to increase the compression. They tested the channel behavior by sending compressed image between two computer and check the reconstructed image. Fouzi Douak et. al [15] proposed a new efficient algorithm for color images compression. After a preprocessing step (mean removing and RGB to YCbCr transformation), the DCT transform is applied and followed by an iterative phase (using the bisection method) including the threshold, the quantization, dequantization, the inverse DCT, YCbCr to RGB transform and the mean recovering. This is done in order to guarantee that a desired quality (fixed in advance using the well known PSNR metric) is checked. For the aim to obtain the best possible compression ratio CR, the next step is the application of a proposed adaptive scanning providing, for each (n, n) DCT block a corresponding (n×n) vector containing the maximum possible run of zeros at its end. The last step is the application of a modified systematic lossless encoder. The efficiency of the proposed scheme is demonstrated by results.

G. K. Kharate and V. H. Patil [16] were implemented the algorithm of image compression using wavelet packet best tree based on Threshold entropy and enhanced RLE, and tested over the set of natural and synthetic images and concluding remarks based on results are discussed. The results show that the compression ratio is good for low frequency (smooth) images, and it is observed that it is very high for gray images. For high frequency images such as Mandrill, Barbara, the compression ratio is good, and the quality of the images is retained too. These results are compared with JPEG-2000 application, and it is found that the results obtained by using the proposed algorithm are better than the JEPG2000.

In this study, a color image compression approach yielding high compression ratios and good reconstructed image quality is proposed. The approach consists of the following steps, first, an input color. Second, the quantized image is divided into n×n non-overlapping square blocks. Each block is classified into two representative edge and non-edge block by applying the canny method to each color component. An edge operator is performed on the bit-map to avoid using the whole bit-map. An efficient coding of the edge detection results will be proposed. Reconstructed images with good quality and reasonable compression ratios will be obtained. Experimental results show the feasibility and efficiency of the proposed approach for color image compression.

The rest of this paper is organized in four sections. Section II describes the edge detection algorithm. Section III describes the proposed algorithm. Section IV presents the experimental results obtained in this paper. Section V draws the conclusion of this work and possible future works

II. Edge Detector (The Canny edge detector)

The [17] introduced an edge detection algorithm based on the idea of applying a filter to the image that is optimal in the identification of step edges, and which is defined so that the output of the filter operation will have a maximum at the location of the edge. The problem of edge detection is then reduced to finding ridges of local maxima in the filtered image. In practice, such as in the implementation of the Canny edge detector in MATLAB (The MathWorks), and as suggested by Canny, the optimal filter is approximated by the derivative of a Gaussian of variable variance. Edges of different width may then be detected by manually choosing different variances.

Since the convolution with the gradient of a function is equal to the gradient of the convolution, the filtering can be efficiently performed by first convolving with a Gaussian to smooth the image and then computing the gradient. The extraction of ridges of maxima is performed by looking for local maxima in the gradient direction. Additionally, the edge pixels are thresholded using two thresholds in order to reduce 'streaking', that is the subdivision of edges into short segments, while simultaneously reducing the probability to extract isolated edge points.

III. Method presentation

As remarked, our compression technique is built around several steps. Each step will be explained in more details in the following:

A. Edge-based DCT transform application

For any color image, each one of the three planes (R,G,B) are partitioned to blocks and classification the blocks into edge (foreground and more important block) and non-edge (background and less important block). The classification process is accomplished by using canny method. The different sizes: 8×8, 16×16 or 32×32 were tested. Each block is DCT transformed. It is clear, that DCT transform (such as the wavelets) concentrate the great part of block energy in few representative coefficients.

B. Proposed Method

The DCT coefficients in each block are then uniformly quantized with quantization step sizes depending on the DCT coefficient. The step sizes are represented in a quantization matrix called the Q-matrix. Different Q-matrices are typically used for the luminance and chrominance components. This quantization stage determines both the amount of compression and the quality of the decompressed image. Large quantization step sizes give good compression but poor visual performance while small quantization step sizes give good visual performance but small compression.

The first technique (PROPSED-1), all AC coefficients of the edge blocks on each component (RGB color space) is used. After quantization and zigzag scan the non-zero of the quantized coefficients is counted and all AC coefficients will be used as the input of the Huffman coding. The non-edge block will be coded using only the DC coefficient. The results of the PROPSED-1 are given in Table 2. The result in this table shows that the PROPSED-1 provides improvement in the bit-rate from 0.13 to 0.16 relative to the JPEG method with a little decreasing of the image quality and PSNR.

The second technique (PROPSED-2), as mentioned earlier, a 70% of the non- zero AC coefficients of the edge blocks on each components (RGB color space) provides a good results. After quantization and zigzag scan the non-zero of the quantized coefficients is counted and only the first 70% of the non- zero AC coefficients on each component will be used as the input of the Huffman coding. The non-edge block will be coded using only the DC coefficient. The results of the PROPSED-2 are given in Table 1.

The third technique (PROPSED-3), a 70% of the non- zero AC coefficients of the edge blocks on R component, 60% of the non- zero AC coefficients of the edge blocks on G component, and 50% of the non- zero AC coefficients of the edge blocks on B component. After quantization and zigzag scan the non-zero of the quantized coefficients is counted and only the first 70% of the non- zero AC coefficients on R component, the first 60% of the non- zero AC coefficients on G component and the first 50% of the non- zero AC coefficients on B component will be used as the input of the Huffman coding. The non-edge block will be coded using only the DC coefficient. The results of the PROPSED-3 are given in Table 1.

The forth technique (PROPSED-4), a 50% of the non- zero AC coefficients of the edge blocks on R component, 50% of the non- zero AC coefficients of the edge blocks on G component, and 50% of the non- zero AC coefficients of the edge blocks on B component provides an accepted results. After quantization and zigzag scan the non-zero of the quantized coefficients is counted and only the first 50% of the non- zero AC coefficients on each component (R, G and B component) will be used as the input of the Huffman coding. The non-edge block will be coded using only the DC coefficient. The results of the PROPSED-4 are given in Table 1.

IV. Experimental Results

Several quality measures can be found in the open literature of the field. The most used measures are (distortion evaluation): The mean squared errors (MSE) and the popular peak signal to noise ratio (PSNR). In the case of gray level images, the PSNR is expressed by

$$PSNR = 10 \times \log_{10} \frac{255^2}{MSE}$$

However, for color RGB images case [4], we have used the relation given in

$$PSNR = 10 \times \log_{10} \left(\frac{255^2 \times 3}{MSE(R) + MSE(G) + MSE(B)} \right)$$

$$MSE = \frac{1}{N \times M} \sum_{i=0}^{N-1} \sum_{j=o}^{M-1} (x_{i,j} - y_{i,j})^2$$

and $x_{i,j}$, $y_{i,j}$ are the original and reconstructed intensities belonging to R, G or B planes, respectively. The size of the compressed image is evaluated with the compression ratio (CR) or with the bite-rate per pixel (bpp) defined by

$$\text{CR} = \frac{\text{Original RGB color image size in bits}}{\text{Compressed image in bits}}$$

and

$$\text{bpp} = \frac{24 \text{ bits}}{\text{CR}}$$

In order to test the efficiency of the proposed approach, we have used the well-known color images: ''Fruit'', ''Airplane'', ''Lena'' of size 512×512 for each one and ''BABOON'', of size 256×256 (see Fig. 1). Different block size (8×8, 16×16 and 32×32) were tested on the different test color images in the RGB space.

Fig. 1. Original test images: (a) Lena, (b) Fruit, (c) BABOON, and (d) Airplane

The performance of the proposed techniques is introduced in this section. The simulation results are compared with each other, with the traditional JPEG results and with recently published methods. The proposed algorithms are applied to a set of color images to study the performance of these algorithms with different types of image.

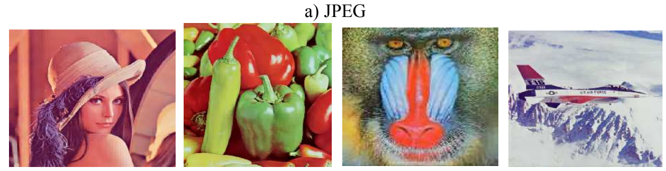
Table 1 show the result of the JPEG technique and the performance of the PROPSED-1, PROPSED-2, PROPSED-3 and PROPSED-4 algorithm, respectively. In Table 1, the canny method is used in the edge extraction processing to study the performance of this technique in the coding process. Moreover, the peak signal to noise ratio (PSNR) of the reconstructed image, MSE (Mean Square Error) and the compression ratio (CR) are given. It is clear that the improvement of the compression ratio relative to the JPEG is small when using the PROPSED-1 technique.

In the first row of Fig. 2, the visual result of the reconstructed image using the JPEG, PROPSED-1,

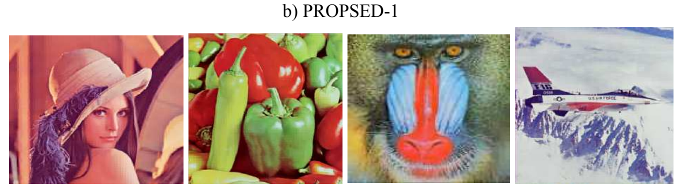
Table 1 : PSNR comparison of the decoded image (in dB) of the JPEG, PROPSED-1, PROPSED-2, PROPSED-3 and PROPSED-4 coding with block size (8×8)

Image		JPEG	PROPSED-1	PROPSED-2	PROPSED-3	PROPSED-4
		Number of non-edge block			Number of edge block	
Lena	R	2033			2063	
	G	1996			2100	
	B	1765			2331	
	MSE	15.164	16.8461	21.9729	23.4713	25.2296
	PSNR	36.322	35.8658	34.7119	34.4254	34.1117
	CR	14.972	16.6383	22.1500	24.0784	26.8532
	bpp	1.6029	1.4425	1.0835	0.9967	0.8937
Fruit	R	1611			2485	
	G	1996			2100	
	B	2012			2084	
	MSE	17.865	19.5585	24.0248	25.8374	27.0409
	PSNR	35.610	35.2174	34.3242	34.0083	33.8106
	CR	14.331	15.9323	21.4217	23.2756	26.0545
	bpp	1.6746	1.5064	1.1204	1.0311	0.9211
BABOON	R	117			907	
	G	102			922	
	B	123			901	
	MSE	43.136	45.0554	53.7736	56.2109	58.8072
	PSNR	31.782	31.5933	30.8251	30.6326	30.4365
	CR	6.7657	7.0470	10.7742	11.8721	13.9569
	bpp	3.5473	3.4057	2.2275	2.0215	1.7196
Airplane	R	2059			2037	
	G	2165			1931	
	B	2121			1975	
	MSE	12.719	13.4592	19.3138	21.0577	23.0780
	PSNR	37.086	36.8406	35.2721	34.8967	34.4988
	CR	14.204	15.4578	20.5880	22.2161	25.1463
	bpp	1.6896	1.5526	1.1657	1.0803	0.9544

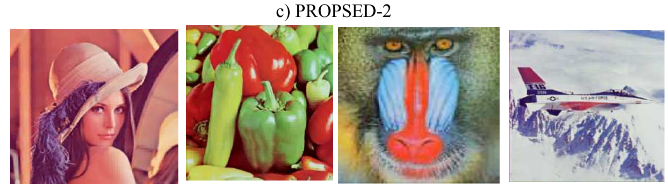
a) JPEG



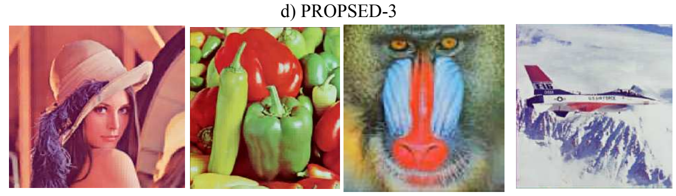
b) PROPSED-1



c) PROPSED-2



d) PROPSED-3



e) PROPSED-4

Fig. 2. The results of the JPEG, PROPSED-1, PROPSED-2, PROPSED-3 and PROPSED-4 techniques, respectively for noise free color images with block size (8×8)

a) PROPSED-1

b) PROPSED-4

Fig. 3. The results of the PROPSED-1 and PROPSED-4 techniques, respectively for noise free color images with block size (16×16)

PROPSED-2, PROPSED-3 and PROPSED-4 techniques, respectively. From Fig. 2, it is clear that the quality of the reconstructed images is accepted.

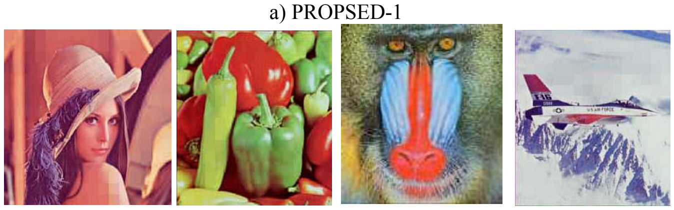
In conclusion, the proposed image coding technique based on edge detection improves the compression ratio from 1:14 to 1:26 when applying the PROPSED-4 technique on Lena and Fruit images. The compression ratio when applying the PROPSED-4 technique on BABOON image is increased from 1:6 to 1:13 and with the Airplane image is increased from 1:14 to 1:25.

Table 2 show the results demonstrating, visibly; the superiority in performance of the proposed technique PROPSED-4 than the proposed technique PROPSED-1. In addition of the high capacity of the proposed algorithm to perform well on color images, we can conclude that the block size 16×16 (and slightly less 32×32) represents, in average, the best choice for the size block.

Fig. 3 and Fig. 4 give visual and quantitative results of the proposed methods (PROPSED-1 and PROPSED-4) with (16×16) and (32×32) block size, respectively.

Fig. 5 show the comparison between PSNR for 16×16 and 8×8 block size of PROPSED-4 for different image, It is observed that the block size 16×16 provides good results than block size of 8×8.

a) PROPSED-1

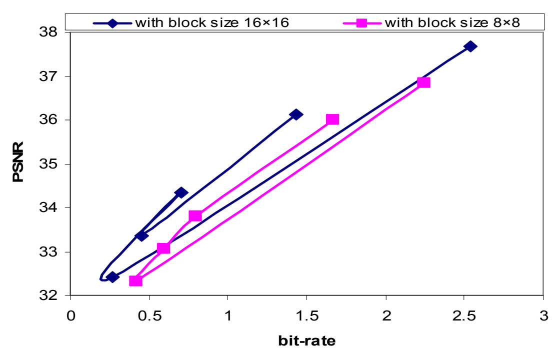


b) PROPSED-4

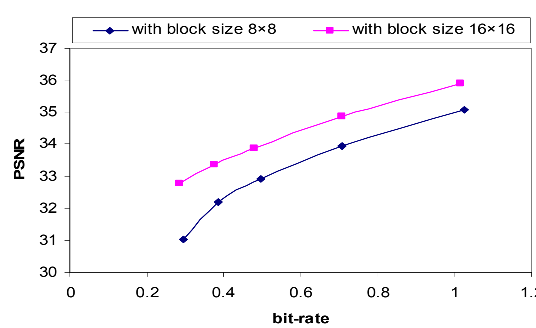
Fig. 4. The results of the PROPSED-1 and PROPSED-4 techniques, respectively for noise free color images with block size (32×32)

TABLE 2: PERFORMANCES IN THE RGB SPACE FOR THE DIFFERENT DCT BLOCK SIZES AND THE DIFFERENT IMAGES

Image		block size (16×16)			block size (32×32)		
		PROPSED-1	**PROPSED-3**	**PROPSED-4**	**PROPSED-1**	**PROPSED-3**	**PROPSED-4**
		Number of non-edge block	Number of edge block		Number of non-edge block		Number of edge block
Lena	R	340	684		37		219
	G	329	695		45		211
	B	258	766		25		231
	MSE	15.6049	22.2625	25.0939	17.5441	24.1009	27.2666
	PSNR	36.1982	34.6551	34.1351	35.6895	34.3105	33.7745
	CR	16.4081	32.3184	37.2690	16.6879	41.2804	48.2178
	bpp	1.4627	0.7426	0.6440	1.4382	0.5814	0.4977
Fruit	R	219	805		16		240
	G	289	735		28		228
	B	279	745		21		235
	MSE	22.6315	28.1880	29.8398	28.0842	32.8982	34.7066
	PSNR	34.5837	33.6302	33.3828	33.6462	32.9591	32.7267
	CR	16.1026	41.6137	50.4446	15.5203	70.3412	86.8326
	bpp	1.4904	0.5767	0.4758	1.5464	0.3412	0.2764
BABOON	R	12	244		0		64
	G	7	249		0		64
	B	11	245		0		64
	MSE	34.1320	49.4925	53.3039	39.1689	50.7938	53.9082
	PSNR	32.7992	31.1854	30.8632	32.2014	31.0727	30.8143
	CR	7.0100	13.0874	15.4817	7.0669	15.2402	18.4414
	bpp	3.4237	1.8338	1.5502	3.3961	1.5748	1.3014
Airplane	R	386	638		61		195
	G	421	603		70		186
	B	409	615		67		189
	MSE	11.4226	18.2980	20.8957	13.4311	19.9088	22.4793
	PSNR	37.5532	35.5068	34.9302	36.8497	35.1403	34.6130
	CR	15.4226	28.0935	33.0633	15.4907	32.8700	39.6330
	bpp	1.5562	0.8543	0.7259	1.5493	0.7301	0.6056



(a)



(b)

Fig. 5. Comparison between PSNR in dB for 16×16 and 32×32 block size of PROPSED-4 for a) Lena and b) Airplane image

TABLE 3: COMPARISON BETWEEN THE PROPOSED METHOD (PROPSED-4) AND THE CBDCT-CABS [15] ALGORITHM.

A) THE CBDCT-CABS [15] ALGORITHM.

image	PSNR	bpp	CR	PSNR	bpp	CR
Block 16×16						
lena	31.959	1.127	21.292	31.79	1.2973	18.5
Airplane	30.372	0.873	27.475	30.477	1.0639	22.55
Fruit	30.167	0.891	26.919	30.074	1.0329	23.23
Average	**30.8326**	**0.964**	**25.228**	30.7803	1.1313	21.43
Block 32×32						
lena	31.994	1.186	20.225	31.901	1.2708	18.88
Airplane	30.417	0.847	28.31	30.426	1.009	23.78
Fruit	30.189	1.021	23.505	30.14	1.0833	22.15
Average	30.8666	1.018	24.013	30.8223	1.1210	21.60

B) THE PROPOSED METHOD (PROPSED-4)

image	PSNR	bpp	CR	PSNR	bpp	CR
Block 16×16						
lena	35.477	1.1143	21.539	35.7880	1.252	19.1581
Airplane	35.472	0.8717	27.531	35.8892	1.016	23.6158
Fruit	34.382	0.8653	27.737	34.6625	1.033	23.2244
Average	**35.110**	**0.9504**	**25.602**	35.4465	1.100	21.9994
Block 32×32						
lena	35.698	1.1788	20.359	35.8782	1.264	18.9749
Airplane	35.488	0.8460	28.368	35.9209	1.006	23.8449
Fruit	34.851	1.0791	22.240	34.8007	1.049	22.8638
Average	35.346	1.0346	23.656	35.5332	1.107	21.8945

The comparison of the numerical quality in terms of PSNR is presented in Table. 3. Notice that the average PSNR gains of our algorithm are nearly to 4.2 dB, 4.4 dB compared with CBDCT-CABS [15] at 16×16, 32×32 block size, respectively. The reconstructed image of Lena, Airplane and Fruit for the proposed method is shown in fig.6 and fig.7 for 16×16, 32×32 block size, respectively. With 32×32 block size, at the low bitrate the test images decoded by proposed method shows several blocking artifact, especially around the edge.

a) b) c)

Fig. 6. PROPSED-4: Compressed images visual and quantitative performance (DCT block size is 16×16): (a) Lena (PSNR=35.7880, bpp=1.2527), (b) Airplane (PSNR=35.8892, bpp=1.0163), and (c) Fruit (PSNR=34.6625, bpp=1.0334)

a) b) c)

Fig. 7. PROPSED-4: Compressed images visual and quantitative performance (DCT block size is 32×32): (a) Lena (PSNR=35.8782, bpp=1.2648), (b) Airplane (PSNR=35.4885, bpp=0.8460), and (c) Fruit (PSNR=34.8515, bpp=1.0791)

V. CONCLUSION

Most traditional compression techniques exploit the statistical characteristics of images to reduce bit rate. These techniques fail to provide acceptable quality at very low bit rates because they do not take into account the properties of human visual perception. In this paper, the new image compression method based on edge detection was introduced firstly. In after section, we proposed an improved compression method. The relationship between two luminance values was considered, and further measures were done. Experimental results demonstrate that the proposed algorithm is capable of delivering attractive results with acceptable visual quality images for 256 x 256 and 512 x 512 color images. The use of variable block sizes in the compression scheme will yield generally higher compression ratios.

Such compression ratio is over conventional JPEG compression ratio. So, the improved method could be an important expansion of JPEG method at higher compression ratio. The further research works are how to apply the improved method with hardware support.

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