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Multi-Channel Image Compression Using JPEG-DCT with RGB Color Model

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Abstract

The rapid growth of digital imaging applications, 9including desktop publishing, multimedia, teleconferencing, and high definition television (HDTV) has increased the need for effective and standardized image compression techniques. Lots of techniques are available for the Single channel image compression i.e. for black and white images. For still image compression, the `Joint Photographic Experts Group' or JPEG standard has been established by ISO (International Standards Organization) and IEC (International Electro-Technical Commission). Since then lots of work had been done on single channel image compression mostly based on JPEG compression. But rapid growth in modern communication demands the direct transmission and storage of Multichannel images i.e. Color images. This arises the need of effective and standardized Multichannel image compression technique. The aim of this paper is to develop and implement an algorithm for compression of multichannel image i.e. color images as well as to speed up the compression of multichannel images with high compression. This paper presents a new method of implementation of available JPEG-DCT technique for multichannel (i.e. Color) image compression using RGB Color Model. The proposed algorithm first divides the multichannel image into its consecutive single channel components, and then single channel JPEG-DCT image compression is applied over each single channel component separately. This leads to the effective solution of the development of multichannel JPEG i.e. multichannel image compression.

Kew words: - Discrete cosine transform, color image compression, RGB color model.

1. Introduction

Image compression addresses the problem of reducing the amount of data required to represent a digital image .The underlying basis of the reduction process is the removal of redundant data. From a mathematical view point, this is a process of transforming a 2-D pixel array into a statistically uncorrelated data set .The transformation is applied prior to storage or transmission of the image [1].Currently image compression is recognized as an “enabling technology”. In addition to the areas just mentioned, image compression is the natural technology for handling the increased spatial resolution of today’s imaging sensors and evolving broadcast television standards. Furthermore image compression plays a major role in many important and diverse applications, including tele-video-conferencing, remote sensing (the use of satellite imagery for weather and other earth resource applications), document and medical imaging facsimile transmission (FAX) [2],[3], and the control of remotely piloted vehicles in military, space and hazardous waste management applications.

2. Image Compression Using Discrete Cosine Transform

Discrete cosine transform (DCT) is widely used in image processing, especially for compression. Some of the applications of two-dimensional DCT involve still image compression and compression of individual video frames. since the late 1980's The JPEG standard has been an effective first solution to the standardization of image compression[4] ,[5] . Although JPEG has some very useful strategies for DCT quantization and compression, it was only developed for low compressions. The 8 × 8 DCT block size was chosen for speed (which is less of an issue now, with the advent of faster processors) not for performance.[6].

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JPEG Compression

The JPEG (Joint Photographic Experts Group) standard has been around for some time and is the only standard for lossy still image compression. There are quite a lot of interesting techniques used in the JPEG standard and it is important to give an overview of how JPEG works. There are several variations of JPEG, but only the 'baseline' method is discussed here.

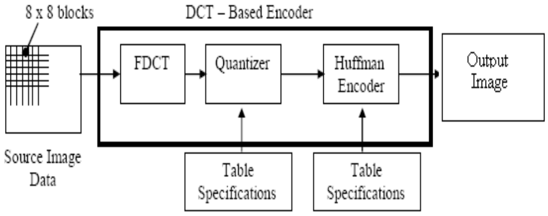

Figure (1) JPEG Encoder

As shown in the figure (1), the image is first partitioned into non-overlapping 8 × 8 blocks. A Forward Discrete Cosine Transform (FDCT) is applied to each block to convert the spatial domain gray levels of pixels into coefficients in frequency domain. To improve the precision of the DCT the image is 'zero shifted', before the DCT is applied. This converts a 0→ 255 image intensity range to a -128→ 127 range, which works more efficiently with the DCT. One of these transformed values is referred to as the DC coefficient and the other 63 as the AC coefficients [4]. After the computation of DCT coefficients, they are normalized with different scales according to a quantization table provided by the JPEG standard conducted by psycho visual evidence. The quantized coefficients are rearranged in a zigzag scan order for further compression by an efficient lossless coding algorithm such as run length coding, arithmetic coding, Huffman coding. The decoding process is simply the inverse process of encoding as shown in figure (2). The decoding process is simply the inverse process of encoding as shown in figure (2).

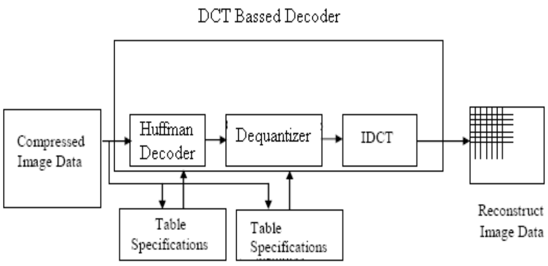

Figure (2). JPEG Decoder

Methodology

The methodology of proposed algorithm is based on the concept of implementation of single channel JPEG-DCT for multichannel images through just dividing the multichannel image into its consecutive single channel components, and then the use of single channel JPEG over the each single channel components separately will leads to the solution of the development of multichannel JPEG i.e. multichannel image compression.

The developed algorithm is discussed below step by step with the help of flow graph shown in the figure (3).

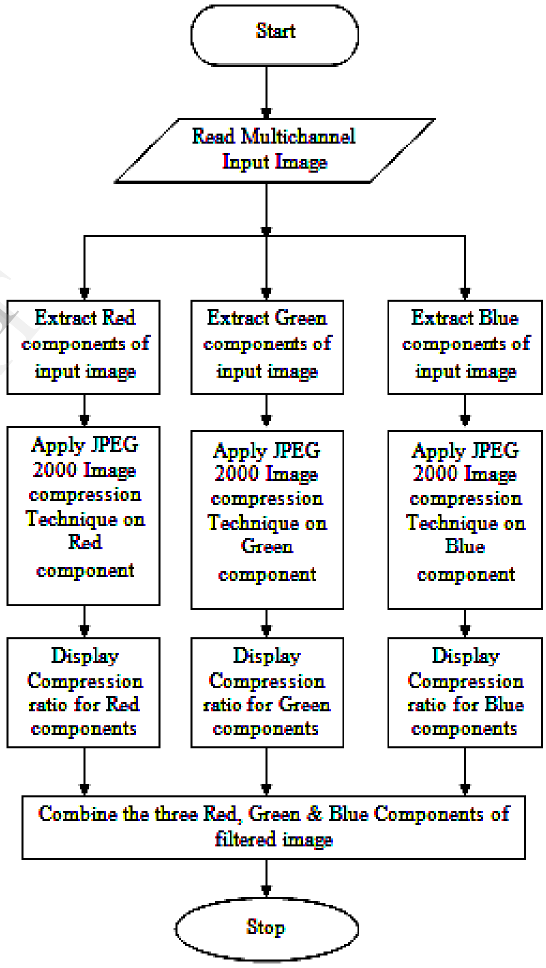

Figure (3) First Developed Algorithm.

3. Result & Discussion

The algorithm has been successfully developed and implemented in MATLAB to develop an efficient multichannel image compression. Now we will show & discuss the various results obtained from the developed algorithm. Since it is not possible to evaluate the performance of any algorithm on the basis of single image, hence for the performance evaluation of the developed algorithm three different multichannel images has been used. These images are shown in figure (4), figure (5) and figure (6). To compare the results obtained from the developed algorithm two most important image compression parameters viz, are used.

1) Compression Ratio.
2) Mean Square Error.

To show the compression and decompression process by using developed algorithm on first input image ie. autumn.tif. Whose size is 206X345 and memory requirement to store is 71070 bytes shown in figure (4). For the performance evaluation of developed algorithm on compression and decompression processes, the value of parameter quality is fixed to 5. ie during the compression process we will remove only 5% information from the original input image. The results obtained after the compression and decompression process are shown from figure (4.1) and figure (4.2).

Figure (4): First Image (autumn.tif) Size 206X345 and memory requirement to store is 71070 bytes.

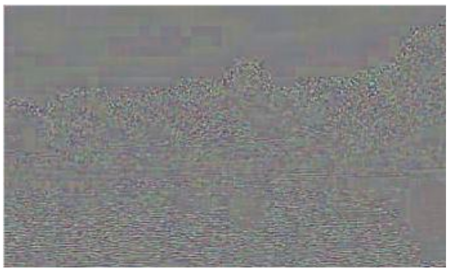

Figure (4.1): First Compressed Image (autumn.tif) Size 206X345 and memory requirement to store is 67872 bytes

Figure (4.2):First decompressed Image (autumn.tif) Size 206X345 and memory requirement to store is 71070 bytes.

The compression parameters obtained after first input image compression and decompression process are as follows.

1	**Bi (size of first input image in bytes)**	**71070 bytes.**
2	**Bc (size of first compressed image in bytes)**	**67872 bytes.**
3	**Bo (size of first decompressed image in bytes)**	**71070 bytes.**
4	**Cr1 (Compression Ratio)**	**23.1081.**
5	**M.S.E1 (Between original & decompressed Image)**	**11.0090**

Similarly the results obtained for second input image ie. (lena.jpeg), who's Size, is 415X445 and memory requirement to store is 180525 bytes are shown from figure (5.1) and figure (5.2).

Figure (5): Second Image (lena.jpeg) Size 415X445 and memory requirement to store is 180525 bytes.

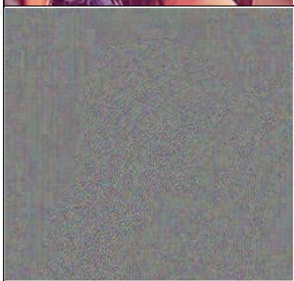

Figure (5.1): Second Compressed Image (lena.jpeg) Size 415X435 and memory requirement to store is 123704 bytes.

Figure (5.2): Second Decompressed Image (lena.jpg).Size 415X445 and memory requirement to store is 180525 bytes.

The compression parameters obtained after second input image compression and decompression process are as follows.

1	**Bi (size of second input image in bytes)**	**180525 bytes.**
2	**Bc (size of second compressed image in bytes)**	**123704 bytes.**
3	**Bo (size of second decompressed image in**	**180525 bytes.**
4	**Cr2 (Compression Ratio)**	**30.3070.**
5	**M.S.E2 (Between original & decompressed Image)**	**8.1334**

Again the results obtained for Third input image ie. (football.jpeg) Size 256X320 and memory requirement to store is 81920 bytes are shown from figure (6.1) and figure (6.2).

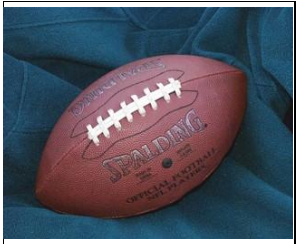

Figure (6): Third Image (football.jpeg) Size 256X320 and memory requirement to store is 81920 bytes.

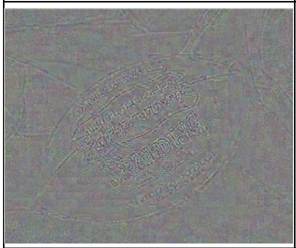

Figure (6.1): Third Compressed Image (football.jpeg) Size 256X320 and memory requirement to store is 42864 bytes.

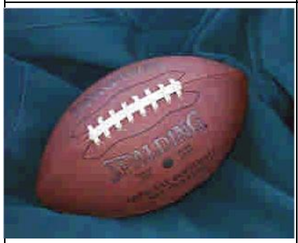

Figure (6.2): Third Decompressed Image (football.jpeg) Size 256X320 and memory requirement to store is 81920 bytes

The compression parameters obtained after third input image compression and decompression process are as follows.

1	**Bi (size of Third input image in bytes)**	**81920 bytes.**
2	**Bc (size of Third compressed image in bytes)**	**42864 bytes.**
3	**Bo (size of Third decompressed image in bytes)**	**81920 bytes.**
4	**Cr3 (Compression Ratio)**	**38.1562.**
5	**M.S.E3 (Between original & decompressed Image)**	**9.6107**

4. Effect of Parameter "Quality" On Image Compression

Up to this stage we have considered the JPEG parameter "Quality" as a constant. Now in this section we will discuss the effect of variation on Quality on the image compression processes, and for that we will show some statistical analysis, like the effect of quality on compression ratio and Error. To examine the effect of variation in quality on compression ratio and error, let us again consider first input image as shown in Figure (5). Now the resultant decompressed images for various values of quality are shown below form Figure (7) to Figure (9).

Figure (7) Decompressed image for quality = 2

Figure (8) Decompressed image for quality = 10

Figure (9) Decompressed image for quality = 30

From the figure 7 to figure 9 it has been clear that as we increase the parameter quality the visual degradation will increase in resultant reconstructed images at the receiving end. The resultant parameters for image compression on the basis of variations in JPEG parameter Quality are recorded in the Table (1).

Table (1)

S.No.	Parameter Quality	Cr-1	Cr-2	Cr-3	M.S.E-1	M.S.E-2	M.S.E-3
1	2	12.2026	15.5315	18.14	17.8006	10.9671	21.9507
2	4	19.7224	25.6074	31.5672	26.6554	17.7579	26.4484
3	6	26.2924	34.9306	44.6334	32.642	22.3956	28.559
4	8	32.5756	43.6104	56.7385	36.8707	26.0687	31.485
5	10	38.1542	51.9564	68.337	38.4482	30.0932	36.2267
6	12	44.482	59.9788	81.616	44.1753	33.4559	37.3148
7	14	50.2203	68.0191	90.2825	46.0266	38.7217	38.0355
8	16	56.5856	76.6967	103.0543	50.9949	39.7816	43.7701
9	18	61.4095	86.2594	113.9121	50.2977	47.2206	56.2501
10	20	66.8217	97.0892	119.6955	59.2806	54.0015	36.8077
11	22	74.9056	109.2366	132.8432	78.7097	51.3614	35.4695
12	24	82.149	118.5473	139.0141	66.0126	54.1269	47.7721
13	26	85.7914	131.0148	145.082	61.3866	64.1057	62.4531
14	28	91.7151	139.8741	150.9841	64.5248	69.2824	73.6536
15	30	96.3526	149.7929	156.7339	65.6618	71.0174	78.8174

Table(1) shows effect of Variation in JPEG Parameter Quality on Image Compression & Decompression using developed algorithm.

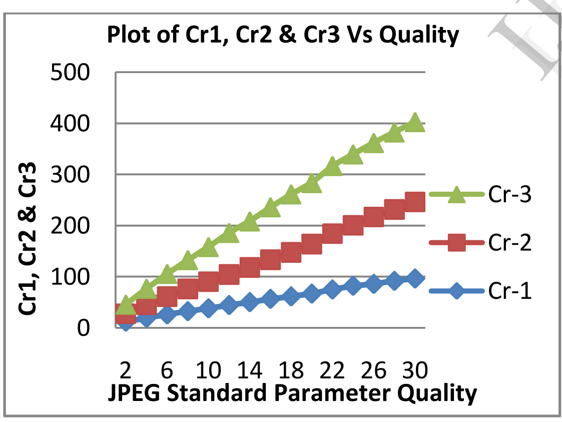

Figure 6.16 Plot of Mean Square Errors for all three images Vs Parameter Quality.

From Table (1) and the plots shown in figure 6.15 and figure 6.16, it can be observed that as we increase the value of quality, though the compression ratio increases but simultaneously it increases the Mean Square Error also, hence there is a requirement of a suitable range of JPEG parameter Quality, which can provide high compression ratio with low Mean Square Error. From the Table (1) and plots the suitable range of parameter quality for first developed algorithm has been found as 4 to 18.

5. Conclusions

In this modern era during transmission and reception, the image storage plays very important and crucial role. In the present scenario the technology development wants fast and efficient result production capability. This paper presented an algorithm for real time multichannel image compression especially for three channel i.e. for color images.

The developed algorithm is found very efficient for compression. Perhaps the image compression using the JPEG standard is not an independent process, its dependent on JPEG parameter known as "Quality". To show the effect of this parameter on color image compression, some statistical analysis has been also done in the paper. According to results of that analysis it is found that as the parameter value increases the compression ratio and Mean square error both are increases. For higher compression ratio we have to select high value of parameter Quality, but the higher value of parameter provides higher Mean square error. Therefore we have some what compromise here with the compression ***ration*** and Mean square error. This leads the requirement of the range of values of parameter Quality that can provide good compression ratio with less error. The suitable range of parameter "quality" found from the statistical analysis is 4 to 18.

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