Image Compression Using Fast 2-D DCT Technique

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***Abstract*— Image Compression is a method, which reduces the size of the data to reduce the amount of space required to store the data. The Discrete cosine transform (DCT) is a method for transforms a signal or image from spatial domain to frequency component. It is a widely used technique in image compression. In this paper, we present a lossless discrete cosine transform (DCT) compression technique for two-dimensional images are proposed. In the several scenarios, the utilization of the proposed technique for image compression resulted in comparable or better performance, when compared to the different modes of the lossless JPEG standard.**

Keywords— Image Compression, JPEG, RLE, Discrete cosine transform (DCT), 2-D DCT.

I. INTRODUCTION

Image compression techniques have been designed to manipulate the statistical redundancy present within real world images. Among the emerging standards are MPEG for compression of motion video, JPEG for compression of images and CCITT H.261 (also known as Px64), for compression of video telephony and teleconferencing.

All three of these standards employ a basic technique known as the discrete cosine transform (DCT), which is developed by Ahmed, Natarajan, and Rao [1974]. It is a lossless compression technique. The DCT is usually applied to reduce spatial redundancy in order to achieve good compression performance. Some of the applications of two-dimensional DCT technique involve image compression and compression of individual video frames. DCT is also useful for transferring multidimensional data from spatial domain to frequency domain, where different operations, like spread spectrum, data compression, data watermarking can be performed in performed manner. The JPEG process is a widely used form of lossy image compression that centers on the Discrete Cosine Transform. DCT and Fourier transforms convert images from spatial-domain to frequency-domain to decorrelate pixels. The JPEG is used for both color and black and-white images.

Compression- Compression is a method, which is reducing the size of the data to reduce the amount of space required to store the data. Compression may be in the form of Data compression, Image compression, Audio data compression, and video compression and Bandwidth compression in Telecommunications. Compression categorized in two broad ways:

Lossless Compression: It never removes any information from the original image. These are referred to as bit-preserving or reversible compression also lossless compression frequently involves some form of entropy encoding and that are based in information theoretic techniques. The following algorithms are lossless-

- CCITT group 3 & 4 compression
- Flate/deflate compression
- Huffman compression
- LZW compression
- RLE compression

Lossy Compression: It creates smaller files by discarding access image data from the original image. Video and Audio compression techniques are most suited to this form of compression.
The following algorithm is Lossy-

- JPEG compression

The advantage of lossy methods over lossless methods is that in some cases, a lossy method can produce a much smaller compressed file than any known lossless method.

Error!Error! Unknown switch argument. Original Cropped Lenna Image (File size: 12KB)	Error!Error! Unknown switch argument. Cropped Lenna Image, Compressed (File size: 85% smaller, 1.8KB)	Error!Error! Unknown switch argument. Cropped Lenna Image, Highly Compressed (File size: 96% smaller, 0.56KB)

Figure 1:Example of Lossy Compression

The above images show the use of lossy compression to reduce the file size of the image. The image is an excerpt of the image of Lenna, a defacto industry-standard test image. The first image is 12,249 bytes. The second image has been compressed (JPEG quality 30) and is 85% smaller, at 1,869 bytes. Notice the loss of detail. The third image has been highly compressed (JPEG quality 5) and is 96% smaller, at 559 bytes. The compression artifacts are much more noticeable and the loss of detail is great.

II. SOME BASIC COMPRESSION METHODS

The JPEG compression: Joint Photographic Expert Group (JPEG) which is commonly used method of compression for photographic images. JPEG compression can be used in a variety of file formats:

- EPS-files
- EPS DCS-files
- JFIF-files
- PDF-files

Firstly the image is partitioned into non-overlapping 8*8 blocks. Then DCT is applied to each block to convert the spatial domain gray level of pixels into coefficients in frequency domain. After the computation of DCT coefficients, they are normalized according to a quantization table with different scales provided by the JPEG standard computed by psycho visual evidence. The quantized coefficients are rearranged in a zigzag scan order for further compressed by an efficient lossless coding algorithm such as run-length coding, Huffman coding. The process may be acquired as such given under:

1. The image first is broken into 8x8 blocks of pixels.
2. The DCT is applied to each block, it is working from left to right, top to bottom.
3. Each block is compressed using quantization table.
4. The array of compressed blocks that comprise the image is stored in a drastically reduced amount of space.
5. When desired, the image is reconstructed through decompression, known as a process that uses the Inverse Discrete Cosine Transform (IDCT).

Run-Length Encoding (RLE): RLE stands for Run Length Encoding. It is a lossless algorithm that only furnishes decent compression ratios in specific types of data.
It is form of data compression in which the same data value occurs in many consecutive data elements (known as *Runs*) are stored as a single data value and count. This is most useful on data that contains many such runs: for example, simple graphic images such as icons, line drawings, and animations. It may be increase the file size because, that doesn't have many runs, and is not useful with files. RLE compression can be used in the following file formats:

- TIFF files
- PDF files

Huffman Coding: The Huffman compression algorithm is invented by David Huffman, formerly a professor at MIT. Huffman compression is a lossless compression algorithm that is apotheosis for compressing text or program files. This credibly explains why it is used a lot in compression programs like ZIP or ARJ.
Huffman encoding can be further optimized in two different ways:

- Adaptive Huffman code dynamically changes the code words concordant to the change of probabilities of the symbols.
- Extended Huffman compression can encode groups of symbols rather than single symbols.

III.PROPOSED METHODOLOGY

The Discrete Cosine Transform: DCT Attempts to decorrelate the image data after decorrelation each transform coefficient can be encoded without dropping off compression efficiency. The DCT and some of its important properties.

The One-Dimensional DCT: The DCT of a list of n real numbers s(x), where x=0, 1, ….., n-1, is the list of length n given by:

$$C(u) = \alpha(u) \sum_{x=0}^{N-1} f(x) \cos \left[\frac{\pi(2x+1)u}{2N}\right]$$

For u= 0, 1, 2, … N-1.

Similarly, the inverse transform is defined as-

$$f(x) = \sum_{x=0}^{N-1} \alpha(u) C(u) \cos \left[\frac{\pi(2x+1)u}{2N}\right]$$

Thus, the first transform coefficient is the coefficient is the average value of the sample sequence.

The Two-Dimensional DCT: The Discrete Cosine Transform (DCT) is one of many transforms that takes its input and transforms it into a linear combination of weighted basis functions. These basis functions are commonly the frequency. The 2-D Discrete Cosine Transform is just a one dimensional DCT applied twice, once in the x direction, and again in the y direction. One can imagine the computational complexity of doing so for a large image. Thus, many algorithms, such as the Fast Fourier Transform (FFT), have been created to speed the computation.

The DCT computes the i, jth entry of the DCT of an image.

$$D(i,j) = \frac{1}{\sqrt{2N}} C(i) C(j) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} p(x,y) \cos \left[\frac{(2x+1)i\pi}{2N}\right] \cos \left[\frac{(2y+1)j\pi}{2N}\right]$$

$$C(u) = \begin{cases} \frac{1}{\sqrt{2}} & if\ u = 0 \\ 1 & if\ u > 0 \end{cases}$$

N is the size of the block that the DCT is applied on. The equation calculates one entry (i, jth) of the transformed image from the pixel values of the original image matrix. For the standard 8*8 block that JPEG compression uses, N equals * and x and y range from 0 to 7. Therefore D (I,j) would be as in equation:

$$D(i,j) = \frac{1}{4} C(i) C(j) \sum_{x=0}^{7} \sum_{y=0}^{7} p(x,y) \cos \left[\frac{(2x+1)i\pi}{16}\right] \cos \left[\frac{(2y+1)j\pi}{16}\right]$$

Because the DCT uses cosine functions, the resulting matrix depends on the horizontal and vertical frequencies. Therefore an image block with a lot of change in has a very random looking resulting matrix of a large value for the first element and zeroes for the other element.

IV. EXPERIMENTAL RESULT

To evaluate the performance of the proposed scheme, 2-D DCT is applied on Lena's image (352*352) as a test image. First DCT applied to rows only through compression factor 2, compression factor 4 and compression factor 8, and observe the result. After that, DCT applied to rows*column. The results are then compared with various compression methods. We used Peak Signal-to Noise Ratio (PSNR) and Mean Square Error (MSE) for a compressed image. This ratio is often used as a quality measurement between the original and compressed image.

To compute the PSNR, first calculate the mean-squared error using the following equation:

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2$$

Where x (m, n) and y (m, n) are the two images of the size m*n. In this case x is the original image and y is the compressed image.

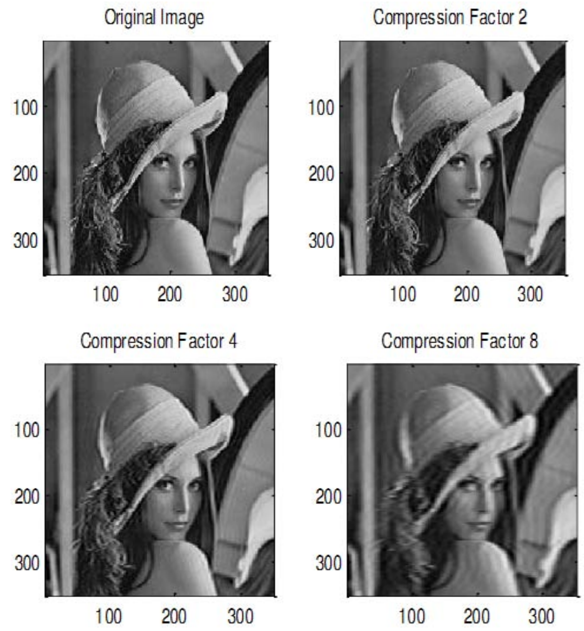
$$PSNR(db) = 10 * \log\left(\frac{255^2}{MSE}\right)$$

The results are then compared with different compression factors as shown in the following table:

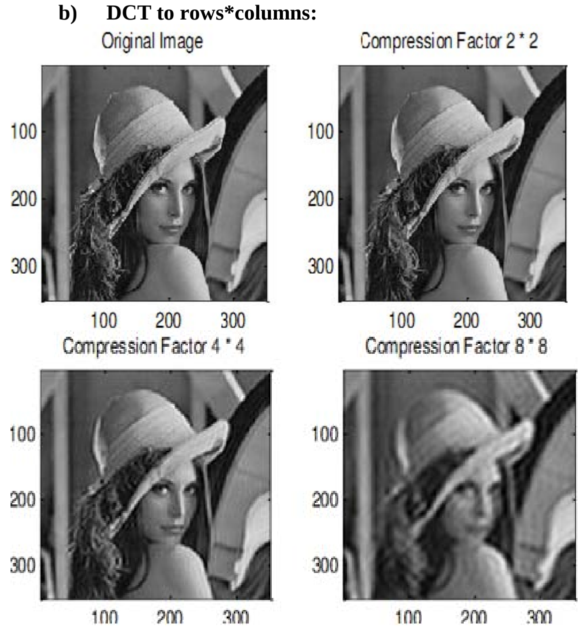
	DCT to rows			DCT to rows*column		
	CF2	***CF4***	***CF8***	***CF2***	***CF4***	***CF8***
MSE	52.64	45.75	40.52	48.64	43.30	38.97
PSNR	0.3538	1.72	5.76	0.8883	3.03	8.24

1) Image of size 352*352:

a) : DCT to rows only



b) DCT to rows*columns:



V. CONCLUSIONS

In this paper, there are 256 possible shades of gray in a black and white picture, and a difference of say 10 is hardly obtrusive to the human eye. DCT takes advantage of redundancies of the data by grouping pixels with similar frequencies. Thus we can also conclude that the difference between original and decompressed image goes on decreasing as there is in increase in image resolution at the same compression ratio. This image compression schemes for images have been presented based on the 2-D DCT. The anticipating results obtained relevant reconstructed image quality as well as preservation of significant image details, while on the other hand accomplishing high compression rates.

High compression ratio and better image quality accomplished which is better than existing methods. This paper has concentrated on development of efficient and effective algorithm for still image compression. Fast and lossless compression algorithm using 2-D DCT is developed. Results show that reduction in encoding time with little degradation in image quality compare to subsisting method. Compression ratio is also increased, while comparing the proposed method with other methods. Our future work involves improving image quality by increasing PSNR value and lowering MSE value.

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