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(Research article)

Analysis of Image Compression Technique using DCT

Virender Poswal[a*], Priyanka [a], Munish Kumar[a]

[a]ECE Deptt. D.C.R.U.S.T, Murthal, Haryana

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Abstract

Image compression is the application of data compression on digital images. Digital images contain large amount of Digital information that need effective techniques for storing and transmitting large volume of data. Image compression techniques are used for reducing the amount of data required to represent a digital image. An Image can be compressed with use of Discrete Cosine Transformation (DCT), quantization encoding are the steps in the compression of the JPEG image format. The 2-D Discrete Cosine transform is used to convert the 8×8 blocks of image into elementary frequency components .The frequency components(DC and AC) are reduced to zero during the process of quantization which is a lossy process .The quantized frequency components are coded into variable length codewords using encoding process. Distortion between the original image and reconstructed image is measured with PSNR(peak signal to noise ratio) with different compression factors. The compression ratio and PSNR val ues are different for different images.. It is found that performance will not remain same for different images even though compression factor was same

Keywords: *Compression Ratio, Compression, PSNR.*

1. Introduction

In today's technological world as our use of and reliance on computers continues to grow, so too does our need for efficient ways of storing large amounts of data and due to the bandwidth and storage limitations, images must be compressed before transmission and storage. However, the compression will reduce the image fidelity, especially when the images are compressed at lower bit rates. The reconstructed images suffer from blocking artifacts and the image quality will be severely degraded under the circumstance of high compression ratios. In order to have a good compression ratio without losing too much of information when the image is decompressed we use DCT[1].A Discrete Cosine Transform (DCT) expresses a sequence of finitely many data points in terms of a sum of cosine functions oscillating at different frequencies. The Fast DCT[2] process is a widely used form of lossy image compression that centers on the Discrete CosineTransform. The DCT transformation is reversible .The DCT works by separating images into parts of differing frequencies. During a step called quantization, where par of compression actually occurs, the less important frequencies are discarded, hence the use of the term"lossy". Then, only the most important frequencies that remain are used to retrieve the image in the decompression process. As a result, reconstructed images contain some distortion; but as we shall soon see, these levels of distortion can be adjusted during the compression stage. The JPEG method is used for both color and black-and white images. The following is a general overview of DCT Compression process.

2. Steps of image compression

There are 2 types of image compression: lossless compression (reversible) and lossy compression (irreversible). In lossy compression, data are discarded during compression and cannot be recovered. Lossy compression achieves much greater compression than lossless technique.

A. Block Diagram of Encoding and Decoding Process

Figure1, show the basic steps that are used in image compression. It consists of DCT encoder and decoder. The first stage of image compression is DCT[5] encoder. It consists of FDCT, quantizer, and entropy encoder. The second stage is DCT decoder[7][8]. It consists of entropy decoder,dequantizer and inverse mapper.

B. Terms used in Image Compression

*Corresponding author's email: virenposwal@yahoo.com

There are various types of terms that are used in calculation of image compression. Some are listed below:

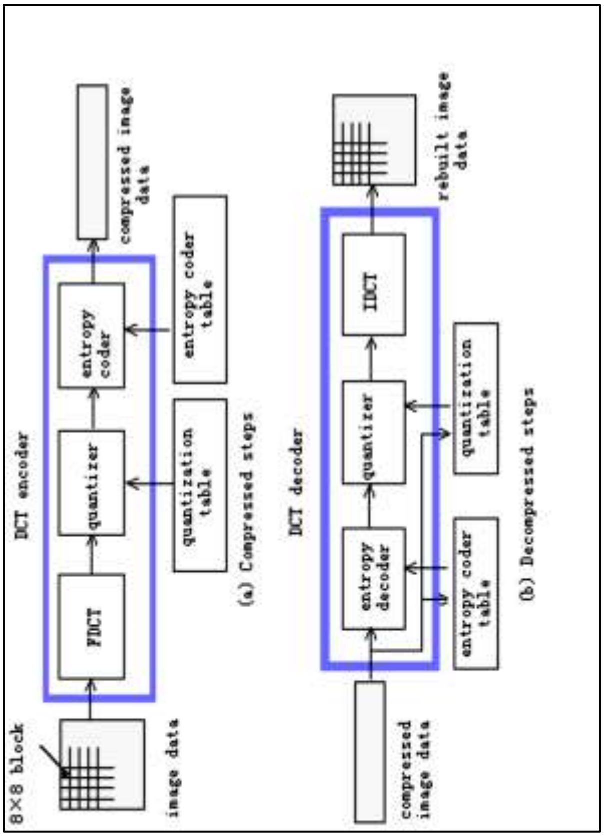

Fig. 1 Basic Steps in Image Compression

(a) Mean Square Error

In statistics, the mean square error or MSE of an estimator is one of many ways to quantify the amount by which an estimator differs from the true value of the quantity being estimated. As a loss function, MSE is called squared error loss. MSE measures the average of the square of the "error" [4] [5]. The error is the amount by which the estimator differs from the quantity to be estimated. The difference occurs because of randomness or A**.** The MSE thus assesses the quality of an estimator in terms of its variation. In a statistical model where the estimate is unknown, the MSE is a random variable whose value must be estimated. This is usually done by the sample mean.

$$MSE = \frac{1}{N}\sum_{i=1}^{N}[R(i) - S(i)]^2$$

Where N is the total number of pixels .R(i) and S(i) are corresponding pixels of original image and reconstructed image

(b) PSNR

MSE indicates how much image degradation exists on a pixel-based [10].On the other hand, PSNR is used to measure the size of errors relative to the peak value of the input sequence and defined as follows:

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

where 255 is the maximum pixel values of the original image which is as per gray scale process. The PSNR and MSE values indicate the quality of reconstructed images: a higher PSNR and a smaller MSE value imply better quality. In general, reconstructed images with PSNR values greater than 30 dB are considered to be in good quality and acceptable to most image applications.

3. Image Compression Process

(a) FDCT

1) The whole image was divided into several pixels of 8×8 blocks (see Figure 2) which is used as the DCT input. The most common variant of discrete cosine transform is the type-II DCT, which is often called simply "the DCT"; its inverse, the type-III DCT, is correspondingly often called simply "the inverse DCT" or "the IDCT". Two related transforms are the discrete sine transforms (DST), which is equivalent to a DFT of real and *odd* functions, and the modified discrete cosine transforms (MDCT), which is based on a DCT of overlapping data. Through the DCT, the energy is concentrated in seldom coefficients.

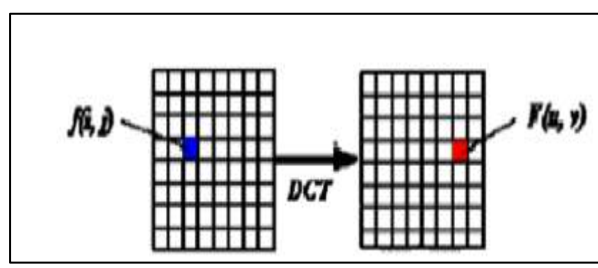

Fig.2 Discrete Cosine Transform (DCT) and Inverse Discrete Cosine Transform

Formula

DCT:

$$F(u,v) = \frac{1}{\sqrt{MN}}C(u)C(v)\sum_{x=0}^{7}\sum_{y=0}^{7}f(x,y)cos\left[\frac{\pi}{2N}(2x+1)u\right]cos\left[\frac{\pi}{2M}(2y+1)v\right]$$

IDCT:

$$f(x,y) = \frac{2}{\sqrt{MN}} \sum_{x=0}^{7} \sum_{y=0}^{7} C(u)C(v)F(u,v) cos\left[\frac{\pi}{2N}(2x + 1)u\right] cos\left[\frac{\pi}{2M}(2y+1)v\right]$$

(b) Quantization:

The human eye is fairly good at seeing small differences in brightness over a relatively large area, but not so good at distinguishing the exact strength of a high frequency brightness variation. This fact allows one to get away with a greatly reduced amount of information in the high frequency components. This is done by simply dividing each component in the frequency domain by a constant for that component and then rounding to the nearest integer. This is the main lossy operation in the compression process. As a result of this, it is typically the case that many of the higher frequency components are rounded to zero, and many of the rest of the components become small numbers. A standard quantization table

$$\begin{bmatrix} 16 & 11 & 10 & 16 & 24 & 40 & 51 & 61 \\ 12 & 12 & 14 & 19 & 26 & 58 & 60 & 55 \\ 14 & 13 & 16 & 24 & 40 & 57 & 59 & 60 \\ 14 & 17 & 22 & 29 & 51 & 87 & 80 & 62 \\ 18 & 22 & 37 & 56 & 68 & 109 & 103 & 77 \\ 24 & 35 & 55 & 64 & 81 & 104 & 113 & 92 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 49 & 64 & 78 & 87 & 103 & 121 & 120 & 101 \\ 72 & 92 & 95 & 98 & 112 & 100 & 103 & 99 \end{bmatrix}$$

Different quantization matrices can be created with variation of compression factors(Q) with multiplying each element of quantization matrix with q.

For (Q>50) q=round$\left[\frac{100-Q}{50}\right]$;

For (Q<50) q=round$\left[\frac{Q}{50}\right]$;

(c) Entropy Encoding:

After the quantization process in each 8×8 block much of the number of elements turn out to be zero.Entropy encoding is an important process which basically reduces the amount of storage space required for the image.Thus to perform entropy encoding which is basically a lossless process to issue variable length codewords to each symbol.Each element of the 8×8 block is scanned and its frequency of occurrence is stored.Depending on probability of occurrence of the symbol the symbols are encoded with Huffman coding technique and an encoder table is maintained.This process is repeated on each successive 8×8 block to generate a string of binary codewords which can be transmitted or stored.The codes generated in the form of binary digits are stored in the Huffman dictionary which can be retrieved during the decompressin step.

(d) Decompression process:

In order to reconstruct the compressed image inverse the binary codewords are decoded with the encoder table and process of dequantization is performed on each 8×8 block.During dequantization process each quantized element is multiplied with corresponding element of quantized matrix and is rounded off

C(i,j)=round[(i,j)*q(i,j)]

C(i,j) is the dequantized element ;d(i,j) is quantized element and q(i,j) is element of quantization matrix.After process of dequantization IDCT process is applied on the each and every element to change the elements back into spatial domain.In the final process of reconstruction evert element is shifted to value between 0 to 255.

4. Performance and Results

Follow the steps above to separately process two pictures (512×512, 8bit/pixel) by coding and then quantizing in reverse as well as IDCT. The pictures before and after treatment are as follow and various parameters are calculated.

Source Entropy : H(u)=-$\sum P(ai) \log P(ai)$

Average Codelength: Lavg=$\sum L(ai)P(ai)$

Compression Rate: CR= $\frac{m}{Lavg}$

Original Image (Lena)

Reconstructed Image(Q=10,PSNR=33.40)

Original Image(Barbara)

Reconstructed Image (Q=20, PSNR=31.27)

Original Image(Boat)

Reconstructed Image (Q=20,PSNR=33.48)

(Lena)				(Barbara)				(Boat)			
Q	CR	PSNR	H(u)	Q	CR	PSNR	H(u)	Q	CR	PSNR	H(u)
10	7.1	33.40	.35	10	6.9	28.41	.44	10	6.5	31.1	.42
20	6.5	36.03	.54	20	6.15	31.27	.73	20	6.29	33.48	.67
50	5.5	38.89	.92	50	4.9	35.57	1.25	50	5.12	36.51	1.16
70	4.9	40.41	1.23	70	4.25	37.95	1.62	70	4.4	38.15	1.52

5. Conclusion and discussion

In this paper we have studied Image compression using DCT and implemented it on Matlab (7.10). The method of this paper is directly to utilize each matrix block with the Huffman coding, though it is not completely to the aim of standard JPEG compression coding intensity, as a whole it has compression rate of the image data, besides when decoding, it can rebuild the image which is accepted in subjective. So this paper develops basic understanding of the image compression process using DCT and its implementation on Matlab.

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