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A Comparitive Analysis Of Lossy Image Compression Algorithms

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ABSTRACT

Image compression is now essential for applications such as transmission and storage in data bases.This paper addressesand discuss about theneed of compression, lossy image compression, and its principles. This paper attempts to give a performance comparison of two algorithms Joint picture expert group and Discrete Cosine Transformalgorithms and discusses the performance comparisonof these algorithms for the images in different resolutions 240 x 240, 800 x 800, 1024 x 1024 in terms of Compression Ratio, Peak signal to noise ratio and elapsed time .This comparison has evaluated that the JPEG algorithm is more efficient than DCT algorithm.

INTRODUCTION

Image compression is the application of data compression on digital images. In effect, the objective is to reduce redundancy of the image data in order to be able to store or transmit data in an efficient form. Uncompressed multimedia (graphics, audio and video) data requires considerable storage capacity and transmission bandwidth. Despite rapid progress in mass-storage density, processor speeds and digital communication system performance, demand for data storage capacity , data transmission bandwidth continues to outstrip the capabilities of available technologies. The recent growth of data intensive multimedia-based web applications have not only sustained the need for more efficient ways to encode signals and images but have made compression of such signals central to storage and communication technology. (Sachin Dhawan, 2011; Mei, T.Y., T.J. Bo, 2010)

Principles Behind Compression:

A common characteristic of most images is that the neighboring pixels are correlated and therefore contain redundant information. The foremost task is to find less correlated representation of the image. Two fundamental components of compression are redundancy and irrelevancy reduction (Subramanya, A, 2001). Redundancy reduction aims at removing duplication from the signal source (image/video). Irrelevancy reduction omits parts of the signal that will not be noticed by the signal receiver, namely the Human Visual System. In general, three types of redundancy can be identified:

A. Coding Redundancy:

A code is a system of symbols used to represent a body of information or set of events. Each piece of information or events is assigned a sequence of code symbols, called a code word. The number of symbols in

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each code word is its length. The 8-bit codes that are used to represent the intensities in the most 2-D intensity arrayscontain more bits than are needed to represent the intensities.

B. Spatial Redundancy and Temporal Redundancy:

The pixels of most 2-D intensity arrays are correlated spatially, information is unnecessarily replicated in the representations of the correlated pixels. In video sequence, temporally correlated pixels also duplicate information.

C. Irrelevant Information:

Most of the 2-D intensity arrays contain information that is ignored by the human visual system and extraneous to the intended use of the image. It is redundant in the sense that it is not used. Image compression research aims at reducing the number of bits needed to represent an image by removing the spatial and spectral redundancies as much as possible.

Lossy Compression Techniques:

Lossy compression allows constructing an approximation of the originaldata, in exchange for better compression ratio.

Methods for lossy compression: (Abhishek Thakur *et al*., 2014)

A.Color space:

Reducing the color space to the most common colors in the image. The selected colors are specified in the color palette in the header of the compressed image. Each pixel just references the index of a color in the color palette, this method can be combined with dithering to avoid posterization (Chunlei Jiang, ShuxinYin, 2010).

B.Chroma subsampling:

This takes advantage of the fact that the human eye perceives spatial changes of brightness more sharply than those of color, by averaging or dropping some of the chrominance information in the image.

C.Transform coding:

This is the most commonly used method. In particular, a Fourier-related transform such as the Discrete Cosine Transform (DCT) is widely used. The more recently developed wavelet transform is also used extensively, followed by quantization and entropy coding.

D.Fractal Compression:

Fractal Image Compression technique identify possible self-similarity within the image and used to reduce the amount of data required to reproduce the image. Traditionally these methods have been time consuming, but some latest methods promise to speed up the process. (Shukla, M.,)

Various Compression Algorithms:

Various types of algorithms are available for compression. It is classified into

1. Lossless compression.
2. Lossy compression.

In this work two lossy compression techniques are considered for performance comparison.

A.JPEG Compression:

JPEG is an algorithm designed to compress images with 24 bits depth or greyscale images. (Rani, B., *et al*., 2009) It is a lossy compression algorithm. One of the characteristics that make the algorithm very flexible is that the compression rate can be adjusted. If we compress a lot, more information will be lost, but the result image size will be smaller. With a smaller compression rate we obtain a better quality, but the size of the resulting image will be bigger. This compression consists in making the coefficients in the quantization matrix bigger when we want more compression, and smaller when we want less compression. The algorithm is based in two visual effects of the human visual system. First, humans are more sensitive to the luminance than to the chrominance. Second, humans are more sensitive to changes in homogeneous areas, than in areas where there is more variation (higher frequencies). JPEG is the most used format for storing and transmitting images in Internet.The JPEG image compression technique consists of 5 functional stages. (Rani, B., *et al*., 2009)

1. An RGB to YCC color space conversion.
2. A spatial subsampling of the chrominance channels in YCC space.
3. The transformation of a blocked representation of the YCC spatial image data to a frequency domain representation using the discrete cosine transform.
4. A quantization of the blocked frequency domain data according to a user-defined quality factor.

5. The coding of the frequency domain data, for storage, using Huffman coding.

B.Discrete Cosine Transform:

The discrete cosine transform (DCT) is a technique for converting a signal into elementary frequency components. Itexpresses a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies. DCTs are important to numerous applications in science and engineering, from lossy compression of audio (e.g. MP3) and images (e.g. JPEG) (where small high-frequency components can be discarded), to spectral methods for the numerical solution of partial differential equations. (Ahmed, N., *et al*., 1974) The use of cosine rather than sine functions is critical for compression, since it turns out that fewer cosine functions are needed to approximate a typical signal, whereas for differential equations the cosines express a particular choice of boundary conditions. (Bhattacharjee, J., 2009)

The algorithm steps are as follows,

1.The input image is N by M;

2.f(i,j) is the intensity of the pixel in row i and column j;

3.F(u,v) is the DCT coefficient in row k1 and column k2 of the DCT matrix.

4.For most images, much of the signal energy lies at low frequencies; these appear in the upper left corner of the DCT.

5.Compression is achieved since the lower right values represent higher frequencies, and are often small - small enough to be neglected with little visible distortion.

6.The DCT input is an 8 by 8 array of integers. This array contains each pixel's gray scale level;

7.8 bit pixels have levels from 0 to 255. (AmanjotKaur, JaspreetKaur., 2012)

Parameters For Image Compression:

The performance of the image compression algorithms can be measured using the following parameters,

A.Compression Ratio:

Data compression ratio is defined as the ratio between the uncompressed size and compressed size.

$$\text{Compression Ratio} = \frac{\text{Uncompressed Size}}{\text{Compressed Size}}$$

B.Peak signal to Noise Ratio:

Peak signal-to-noise ratio, often abbreviated PSNR, is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale. (Liu, W., *et al*., 2010)

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

$$PSNR = 10log_{10}\left(\frac{MAX^2}{MSE}\right)$$

$$= 20log_{10}\left(\frac{MAX}{\sqrt{MSE}}\right)^2$$

C.Time Factor:

The time taken for the compression and decompression is taken into account for analyzing the efficiency of the algorithm. If an algorithm takes more time to run it will not be suitable for any implementation.

RESULTS AND DISCUSSIONS

The image taken forimplementing the DCT and JPEG algorithms is shown in the fig.1. This image is taken at various resolutions for performance comparison.

Fig. 1: Gray scale image of a dog

A.Analysis of JPEG Algorithm:

The comparative analysis of JPEG compression is given in the *table 1*.The result shows that as the size increases the efficiency of the algorithm also increases. In lossy compression techniques the efficiency of the algorithm increases with respect to the size. The compressed image size decreases as the size increases.The peak signal to noise ratio is calculated using mean square error rate and the signal to noise ratio.

Table 1: Experimental comparison of JPEG algorithm

Image Resolution	Image Size Before Compression (in Bytes)	Image Size After Compression (in Bytes)	CR	Time Taken	PSNR
120x120	3239	2012	14.47	1.049	36.76
240x240	8754	6120	24.97	3.31	37.54
800x800	74425	49645	36.41	35.56	38.12
1024 x1024	123832	81025	36.72	63.47	38.90

**CR-Compression Ratio*

B.Analysis of DCT Algorithm:

The comparative analysis of DCT compression is given in the *table 2*.The result shows that as the size increases the efficiency of the algorithm increases gradually. The compressed image size decreases as the size increases. The peak signal to noise ratio is calculated using mean square error rate and the signal to noise ratio.

Table 2: Experimental comparison ofDCT algorithm

Image Resolution	Image Size Before Compression (in Bytes)	Image Size After Compression (in Bytes)	CR	Time Taken	PSNR
120x120	3239	2318	6.21	0.676	33.47
240x240	8754	5617	10.25	0.78	34.62
800x800	74425	27489	23.28	1.417	37.30
1024x1024	123832	39151	26.78	2.12	38.87

**CR-Compression Ratio*

The performance comparison of both the algorithms are shown in the figure2,figure3, figure4, figure5.The performance parameters Compression ratio, time taken and PSNR values are taken for comparision.The comparison for the image in 120 X 120 resolution is shown in fig 2.It shows that JPEG compression has delivered good compression ratio compared to DCT compression. And the PSNR values shows good result in JPEG compression than DCT, which indicates that the reconstruction of image quality is good. But the time taken by the JPEG is more when compared to DCT.The comparison for the image in 240 X 240 resolutions is shown in fig 3.The PSNR value and the Compression ratio of JPEG algorithm is gradually showing good performance.The comparison for the image in 800 X 800 resolutions is shown in fig 4.The comparison for the image in 1024 X 1024 resolutions is shown in fig 5.The PSNR value and the Compression ratio of JPEG algorithm is gradually increasing which is very suitable for transmission purpose.

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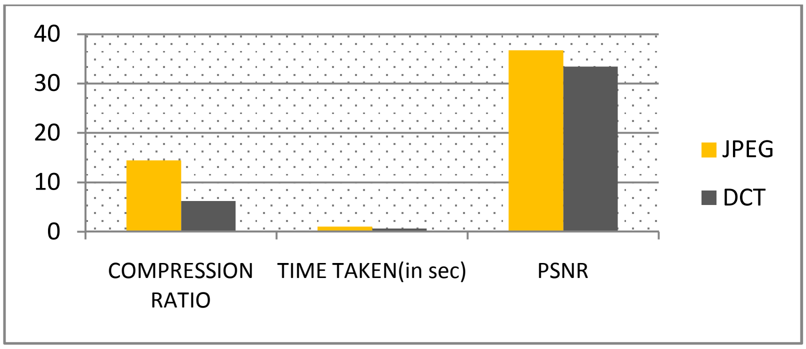

Fig. 2: Comparison graph for the image at 120 X 120 resolutions.

Fig.2 shows the comparison graph for the image at 120 X 120 resolution. It is clear that the compression ratio and psnr ratio is better for JPEG algorithm. In JPEG compression the image is divided into 8 X 8 blocks.JPEG compression consists of making the coefficients in the quantization matrix bigger when we wantmore compression, and smaller when we want less compression. So the compression ratio is better when compared to DCT algorithm. But the time taken for algorithm is little more than DCT algorithm.

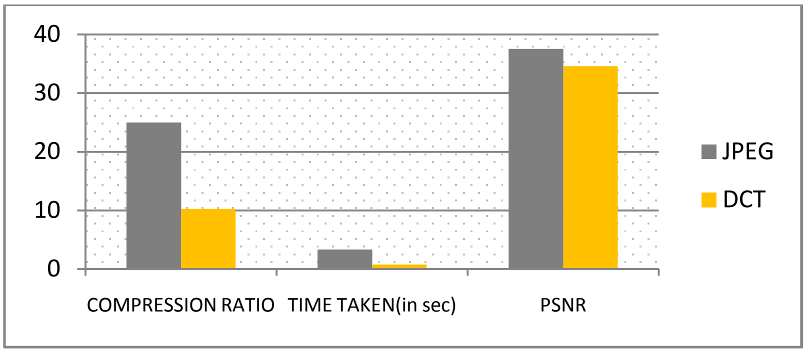

Fig. 3: Comparison graph for the image at 240 X 240 resolution

Fig.3 shows the comparison graph for the image at 240 X 240 resolutions. As the resolution increases the time taken for the algorithm increases abruptly. But the time taken by DCT algorithm remains approximately in a same range.

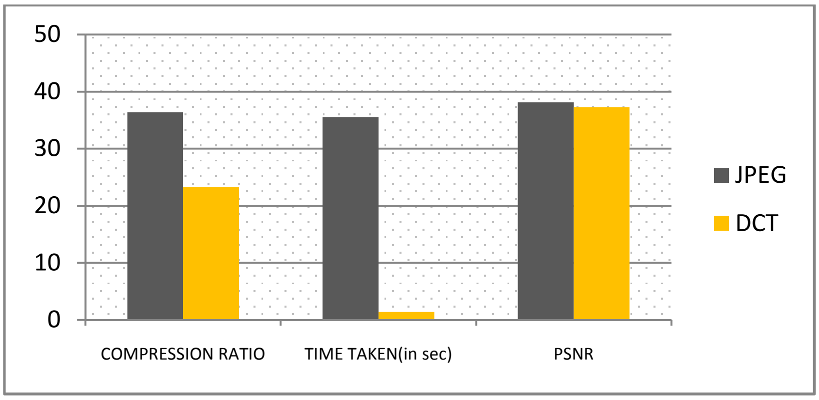

Fig. 4: Comparison graph for the image at 800 X 800 resolution

Fig.4 shows the comparison graph for the image at 800 X 800 resolution. At resolution 800 X 800 the image compression ratio increases. The DCT algorithm eliminates the high frequency components so that the algorithm runs much faster than JPEG algorithm.

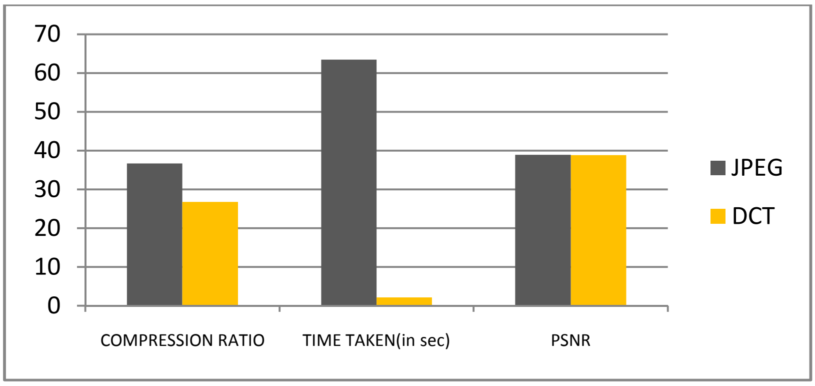

Fig. 5: Comparison graph for the image at 1024 X 1024 resolution

The comparison graph for the image at 1024 X 1024 resolutions is shown in Fig.5. At 1024 X 1024 resolution the PSNR value is almost same for both the algorithm which shows that both the algorithms are better for images with high resolution.

Conclusions:

This work has summarized the efficiency of both the algorithms by comparing compression ratio,time and PSNR values.From this work it is clear that, the JPEG algorithm is more efficient than the DCTalgorithm for image compressions. The JPEG compression takes more time as the size increases compared to DCT. The Compression ratio of JPEG is more which is suitable for storage and transmission.In recent advanced methods the DCT is applied in JPEG image compression.

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