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Image Compression a Learning Approach: Survey

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ABSTRACT
Due to the increasing requirements for transmission of images in computer, mobile environments, the research in the field of image compression has increased significantly. Image compression plays a crucial role in digital image processing, it is also very important for efficient transmission and storage of images. When we compute the number of bits per image resulting from typical sampling rates and quantization methods, we find that Image compression is needed. Therefore development of efficient techniques for image compression has become necessary. This paper addresses about various image compression techniques. On the basis of analyzing the various image compression techniques this paper presents a survey of existing research papers. In this paper we analyze different types of existing method of image compression.
***keywords*:-** Image Compression, JPEG, Discrete Cosine Transform.

I. INTRODUCTION

An image is an artefact that depicts or records visual perception. Images are important documents today; to work with them in some applications there is need to be compressed. Compression is more or less it depends on our aim of the application. Image compression plays a very important role in the transmission and storage of image data as a result of and storage limitations. The main aim of image compression is to represent an image in the fewest number of bits without losing the essential information content within an original image. Compression [3] techniques are being rapidly developed for compress large data files such as images. With the increasing growth of technology a huge amount of image data must be handled to be stored in a proper way using efficient techniques usually succeed in compressing images. There are some algorithms that perform this compression in different ways; some are lossless and lossy. Lossless keep the same information as the original image and in lossy some information loss when compressing the image. Some of these compression techniques are designed for the specific kinds of images, so they will not be so good for other kinds of images. In Some algorithms let us change few parameters they use to adjust the compression better to the image. Image compression is an application of data compression that encodes the original image with fewer bits. The objective of image compression [1] is to reduce the redundancy of the image and to store or transmit data in an efficient form. The compression ratio is defined as follows:

Cr= N1/N2

Where N1 is the data of the actual image and N2 is the data of compressed image.

A. Principles Behind Compression

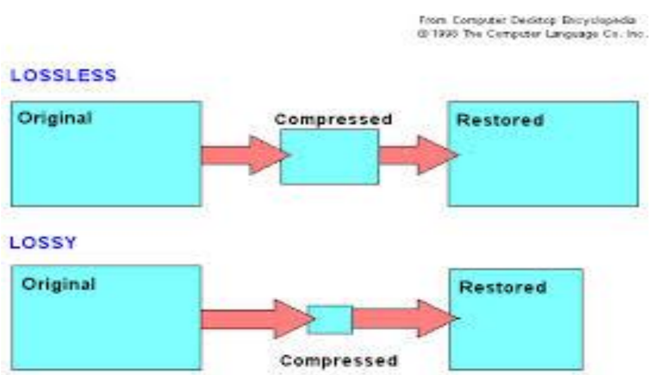
Image Compression addresses the problem of reducing the amount of data required to represent the digital image. We can achieve compression by removing of one or more of three basic data redundancies:

(1) Spatial Redundancy or correlation between neighboring pixels.

(2) Due to the correlation between different color planes or spectral bands, the Spectral redundancy is founded.

(3) Due to properties of the human visual system, the Psycho-visual redundancy is founded.

We find the spatial and spectral redundancies when certain spatial and spectral patterns between the pixels and the color components are common to each other and the psycho-visual redundancy produces from the fact that the human eye is insensitive to certain spatial frequencies. Various techniques can be used to compress the images to reduce their storage sizes as well as using a smaller space. We can use two ways to categorize compression techniques. [13][14]



B. Lossy Compression

Lossy compression techniques are used in images where we can sacrifice some of the finer details in the image to save a little more bandwidth or storage space.

C. Lossless compression

Lossless Compression System aims at reducing the bit rate of the compressed output without any distortion of the image. The bit-stream after decompression is identical to the original bit stream.

II. BENEFITS OF COMPRESSION

1. It provides a believable cost savings involved with sending less data over the switched telephone network where the cost of the call is really usually based upon its duration.

2. It not only reduces storage requirements but also overall execution time.

3. It reduces the probability of transmission errors since fewer bits are transferred.

4. It provides a level of security against unlawful monitoring.

III. COMPARISON BETWEEN LOSSLESS AND LOSSY TECHNIQUES

In lossless compression schemes, the reconstructed image, after compression, is numerically identical to the original image. However lossless compression can only achieve a modest amount of compression. An image reconstructed following lossy compression contains degradation relative to the original. Often this is because the compression scheme completely discards redundant information. However, lossy schemes are capable of achieving much higher compression. On the bases of our requirements image compression techniques are broadly bifurcated in following two major categories.

A) Lossless image compression

B) Lossy image compression

A) Lossless Compression Techniques:

Lossless compression compresses the image by encoding all the information from the original file, so when the image is decompressed, it will be exactly identical to the original image. Examples of lossless [2] image compression are PNG and GIF. When to use a certain image compression format really depends on what is being compressed.

1) Run Length Encoding: Run-length encoding (RLE) is a very simple form of image compression in which runs of data are stored as a single data value and count, rather than as the original run. It is used for sequential data and it is helpful for repetitive data. In this technique replaces sequences of identical symbol (pixel), called runs. The Run length code for a grayscale image is represented by a sequence {Vi , Ri } where Vi is the intensity of pixel and Ri refers to the number of consecutive pixels with the intensity Vi as shown in the figure. This is most useful on data that contains many such runs for example, simple graphic images such as icons, line drawings, and animations. It is not useful with files that don't have many runs as it could greatly increase the file size. Run-length encoding performs lossless image compression [4]. Run-length encoding is used in fax machines.

2) Entropy Encoding: In information theory an entropy encoding is a lossless data compression scheme that is independent of the specific characteristics of the medium. One of the main types of entropy coding creates and assigns a unique prefix-free code for each unique symbol that occurs in the input. These entropy encoders then compress the image by replacing each fixed-length input symbol with the corresponding variable-length prefix free output codeword.

3) Huffman Encoding: In computer science and information theory, Huffman coding is an entropy encoding algorithm used for lossless data compression. It was developed by Huffman. Huffman coding [8] today is often used as a "back-end" to some other compression methods. The term refers to the use of a variable-length code table for encoding a source symbol where the variable-length code table has been derived in a particular way based on the estimated probability of occurrence for each possible value of the source symbol. The pixels in the image are treated as symbols. The symbols which occur more frequently are assigned a smaller number of bits, while the symbols that occur less frequently are assigned a relatively larger number of bits. Huffman code is a prefix code. This means that the (binary) code of any symbol is not the prefix of the code of any other symbol.

4) Arithmetic Coding: Arithmetic coding is a form of entropy encoding used in lossless data compression. Normally, a string of characters such as the words "hello there" is represented using a fixed number of bits per character, as in the ASCII code. When a string is converted to arithmetic encoding, frequently used characters will be stored with little bits and not-so-frequently occurring characters will be stored with more bits, resulting in fewer bits used in total. Arithmetic coding differs from other forms of entropy encoding such as Huffman coding[10] in that rather than separating the input into component symbols and replacing each with a code, arithmetic coding encodes the entire message into a single number.

B) Lossy Compression Techniques:

Lossy compression as the name implies leads to loss of some information. The compressed image is similar to the original uncompressed image but not just like the previous as in the process of compression [9]some information concerning the image has been lost. They are typically suited to images. The most common example of lossy compression is JPEG. An algorithm that restores the presentation to be the same as the original image is known as lossy techniques. Reconstruction of the image is an approximation of the original image, therefore the need of measuring of the quality of the image for lossy compression technique. Lossy compression technique provides a higher compression ratio than lossless compression. Major performance considerations of a lossy compression scheme include:

1) Compression ratio

2) Signal to noise ratio

3) Speed of encoding & decoding

Lossy image compression techniques include following schemes:

1) ***Scalar Quantization:*** The most common type of quantization is known as scalar quantization. Scalar quantization, typically denoted as Y=Q (x), is the process of using a quantization function Q to map a scalar (one-dimensional) input value x to a scalar output value Y. Scalar quantization can be as simple and intuitive as rounding high-precision numbers to the nearest integer, or to the nearest multiple of some other unit of precision.

2) Vector Quantization*:* Vector quantization (VQ) is a classical quantization technique from signal processing which allows the modelling of probability density functions by the distribution of prototype vectors. It was originally used for image compression. It works by dividing a large set of points (vectors) into groups having approximately the same number of points closest to them. The density matching property of vector quantization is powerful, especially for identifying the density of large and high-dimensioned data. Since data points are represented by the index of their closest centriod commonly occurring data have low error, and rare data high error. This is why VQ is suitable for lossy data compression. It can also be used for lossy data correction and density estimation.

IV. DCT TRANSFORMATION

The most popular technique for image compression, over the past several years, was discrete cosine transform (DCT). Its selection as the standard for JPEG is one of the major reasons for its popularity. DCT is used by many Non-analytical applications such as image processing and signal-processing DSP applications such as video conferencing. The DCT is used in transformation for data compression. DCT is an orthogonal transform, which has a fixed set of basis function. DCT is used to map an image space into a frequency. [15]DCT has many Advantages: It has the ability to pack energy in the lower frequencies for image data. It has the ability to reduce the blocking artifact effect and this effect results from the boundaries between sub-images become visible. [18]

We explain the basics of JPEG compression and decompression in the rest of this paper.

A. JPEG COMPRESSION

JPEG Standard is the very well known ISO/ITU-T standard created in the late 1980s. Jpeg standard is targeted for full-color still frame applications. One of the most common compression standards is the JPEG standard. Several modes are defined for JPEG including baseline,[1][2][3]lossless, progressive and hierarchical.

The most common mode uses the discrete cosine transform is the JPEG baseline coding system, also it is suitable for most compression applications. Despite being developed for low compressions JPEG it is very helpful for DCT quantization and compression. JPEG compression reduces file size with minimum image degradation by eliminating the least important information. But it is considered a lossy image compression technique because the final image and the original image are not completely the same and in lossy compression the information that may be lost and missed is affordable. JPEG compression is performed in Sequential steps. [11][20][21][22]

JPEG Process Steps for color images

This section presents jpeg compression steps

1. An RGB to YCbCr color space conversion (color specification)
2. Original image is divided into blocks of 8 x 8.
3. The pixel values within each block range from [-128 to 127] but pixel values of a black and white image range from [0-255] so, each block is shifted from [0-255] to [-128 to 127].
4. The DCT works from left to right, top to bottom thereby it is applied to each block.
5. Each block is compressed through quantization.
6. Quantized matrix is entropy encoded.
7. Compressed image is reconstructed through reverse process. This process uses the inverse Discrete Cosine Transform (IDCT).

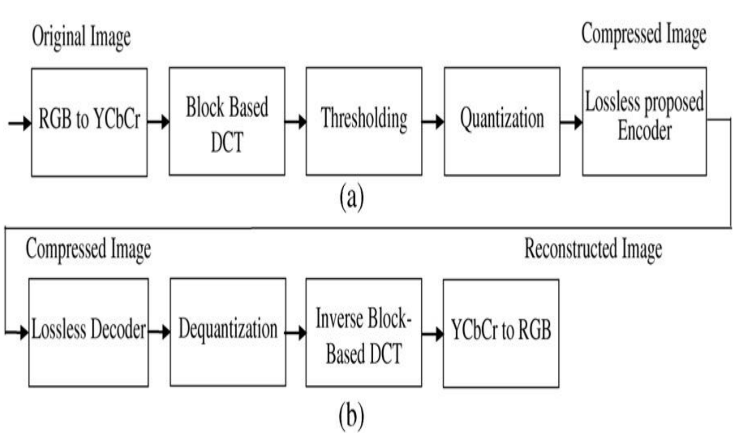


Fig. 1. Compression algorithm scheme: (a) compression step and (b) decompression step

V. DISCRETE COSINE TRANSFORM

After color coordinate conversion, the next step is to divide the three color components of the image into many 8×8 blocks. For an 8-bit image, in the original block each element falls in the range [0,255]. Data range that is centered on zero is produced after subtracting The mid-point of the range (the value 128) from each element in the original block, so that the modified range is shifted from [0,255] to [-128,127]. Images are separated into parts of different frequencies by the DCT. The quantization step discards less important frequencies and the decompression step uses the important frequencies to retrieve the image. This equation gives

The forward 2D_DCT transformation:

Forward DCT (1.1)

$$F(u,v) = \frac{2c(u)c(v)}{N} \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} f(m,n) \cos\left(\frac{2m+1}{2N} u\pi\right) \cos\left(\frac{2n+1}{2N} v\pi\right)$$

$$u = 0,1,\ldots,N-1 \quad v = 0,1,\ldots,N-1$$

where

$$c(k) = \frac{1}{\sqrt{2}} \text{ for } k = 0$$
$$= 1 \text{ otherwise}$$

Inverse DCT (1.2)

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

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

Which can be written in matrix form, where the rows of [T] are the DCT basis vectors, as:

$$[f]_{NxN}=[T^T]_{NxN}[F]_{NxN}[T]_{NxN}$$

$$[F]_{NxN}=[T]_{NxN}[f]_{NxN}[T^T]_{NxN}$$

The f(x,y) is the value of each pixel in the selected 8×8 block, and the F(u,v) is the DCT coefficient after transformation. The transformation of the 8×8 block is also a 8×8 block composed of F(u,v). The DCT is closely related to the DFT. Both of them taking a set of points from the spatial domain and transform them into an equivalent representation in the frequency domain. However, why DCT is more appropriate for image compression than DFT? The two main reasons are:

1) The DCT can concentrate the energy of the transformed signal in low frequency, whereas the DFT can not. According to Parseval's theorem, the Energy is the same in the spatial domain and in the frequency domain. Because the human eyes are less sensitive to the low frequency component, we can focus on the low frequency component and reduce the contribution of the high frequency component after taking DCT.
2) For image compression, the DCT can reduce the blocking effect than the DFT. After transformation, the element in the upper most left corresponding to zero frequency in both directions is the "**DC coefficient**" and the rest are called "**AC coefficients**."

VI. CONCLUSION AND FUTURE SCOPE

Image compression is used for managing images in digital format. This paper has been focused on the Fast and efficient lossy coding algorithms JPEG for image Compression /Decompression using Discrete Cosine transform. We also briefly introduced the principles behind the Digital Image compression and various image compression methodologies and the jpeg process steps including DCT, quantization, entropy encoding. Our future work involves improving image quality by increasing PSNR value and lowering MSE value

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