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Image Compression Techniques- A Review

Khobragade P. B., Thakare S. S.

Department of Electronics and Telecommunication, Amravati University
Govt. College of Engg. Amravati, Maharashtra, India

***Abstract*— An image, in its original form, contains huge amount of data which demands not only large amount of memory requirements for its storage but also causes inconvenient transmission over limited bandwidth channel. So one of the important factors for image storage or transmission over any communication media is the image compression. Compression makes it possible for creating file sizes of manageable, storable and transmittable dimensions. Image compression reduces the data from the image in either lossless or lossy way. In lossless image compression retrieves the original image data completely, it provides very low compression. Here different lossless image compression techniques through which high compression ratio be achieved are discussed.**

For low power and lossless image compression, the image quality will be measured by comparing certain performances parameter such as *Compression Ratio, Peak Signal-to-Noise Ratio Mean Square Error.*

***Keywords*— DCT, DWT, Decompression, Image compression technique, Huffman Coding, Run Length Encoding, Compression, Run Length Encoding, Transform Coding, Loss less and lossy image compression, IWT**.

I. INTRODUCTION

The Use Of Digital Images Is Increasing Rapidly. Along With This Increasing Use Of Digital Images Comes The Serious Issue Of Storing And Transferring The Huge Volume Of Data Representing The Images Because The Uncompressed Multimedia (Graphics, Audio And Video) Data Requires Considerable Storage Capacity And Transmission Bandwidth. The Latest Growth Of Data Intensive Multimedia Based Web Applications Has Put Much Pressure On The Researchers To Find The Way Of Using The Images In The Web Applications More Effectively, Internet Teleconferencing, High Definition Television (HDTV), Satellite Communications, Medical Imaging And Digital Storage Of Movies Are Not Feasible Without A High Degree Of Compression. Compression Is Useful Because It Helps Reduce The Consumption Of Expensive Resources Such As Hard Disk Space Or Transmission Bandwidth. Image Compression Is Achieved When Redundancies Are Reduced Or Eliminated. An Image's File Size Can Be Reduced With Or Without A Loss In Quality Of The Image; These Are Called Lossy Compression And Lossless Compression, Respectively.

A. *Principle behind Compression*

Digital image is basically array of various pixel values. A common characteristic of most images is that the neighboring pixels are correlated and therefore contain redundant information. The foremost task then is to find less correlated representation of the image [1]. By using the compression algorithms redundant bits are removed from the image so that image size is reduced and the image is compressed. Two fundamental components of compression are redundancy and irrelevancy reduction

a. Redundancies reduction aims at removing duplication from the signal source (image/video).

b. Irrelevancy reduction omits parts of the signal that will not be noticed by the signal receiver, namely the Human Visual System.

In an image, which consists of a sequence of images, there are three types of redundancies [2], [3] in order to compress file size. They are:

a. Coding redundancy: Fewer bits to represent frequently occurring symbols.

b. Interpixel redundancy: Neighboring pixels have almost same value.

c. Psycho visual redundancy: Human visual system cannot simultaneously distinguish all colours**.**

II. METHODS

A. *Compression methods*

Compression can be divided into two categories, as Lossless and Lossy compression. In lossless Compression, the reconstructed image after compression is numerically identical to the original image.

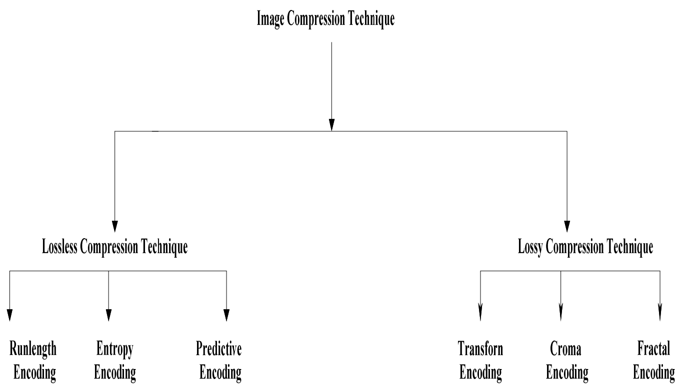

Fig. 1 Image Compression Technique

In lossy compression scheme, the reconstructed image contains degradation relative to the original. Lossy technique causes image quality degradation in each compression or decompression step [4].

B. *Lossy Compression Technique*

Lossy compression reduces a file by permanently eliminating certain information, especially redundant information. When the file is uncompressed, only a part of the original information is still there (mostly not noticed by user). Lossy compression is generally used for video and sound, where a certain amount of information loss will not be detected by most users. The JPEG image file, commonly used for photographs and other complex still images on the Web, is an image that has lossy compression. Using JPEG compression, the creator can decide how much loss to introduce and make a trade-off between file size and image quality.

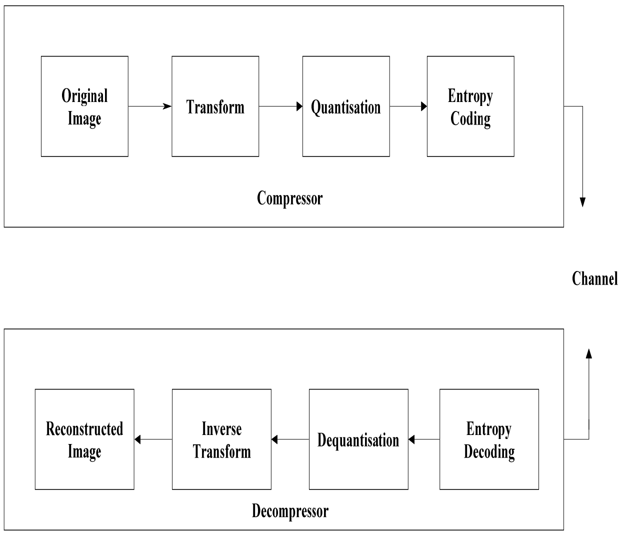

Fig. 2 Lossy Image Compression

Generally most lossy compressors (Fig. 2) are three-step algorithms, each of This is in accordance with three kinds of redundancy mentioned above.

The first stage is a transform to eliminate the inter-pixel redundancy to pack information efficiently. Then a quantizer is applied to remove psycho-visual redundancy to represent the packed information with as few bits as possible. The quantized bits are then efficiently encoded to get more compression from the coding redundancy.
Following lossy image compression coding is used
a. Transform Coding
b. Croma Coding
c. Fractal Coding
d. Vector quantization

C. Lossless Compression Technique

With lossless compression, every single bit of data that was originally in the file remains after the file is uncompressed.

All of the information is completely restored. This is generally the technique of choice for text or spreadsheet files, where losing words or financial data could pose a problem.

Lossless compressors (Fig. 3) are usually two-step algorithms. The first step transforms the original image to some other format in which the inter-pixel redundancy is reduced. The second step uses an entropy encoder to remove the coding redundancy. The lossless decompressor is a perfect inverse process of the lossless compressor.

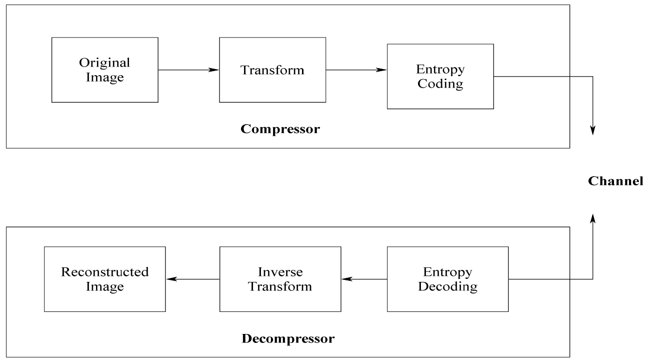

Fig. 3 Lossless Compression Technique

D. Lossless Methods Model

In Image compression, there are different lossless image compressions methods are use discussed below

1) Lossless methods based on substitution Models: The early methods used to compress images were based more on substitution techniques than. These techniques made use of the existing redundancy in the data (pixels) of an image, through the relationship of pixels with the adjacent pixels [8]. The most significant methods used by these models are Bitmap Compression and RLE Run Length Encoding.

2) Lossless methods based on statistical models: The compression methods based on this model arise from the modern information theory supported by the works of C.E. Shannon, R.M-. Fano, and David Huffman. The statistical model can be static or adaptive. Statistical models exploit the redundancy in pixels according to the probability of occurrence in the image. The measure of the model's efficiency is the approximation to the entropy of the image. The most representative methods are Shannon-Fano Coding , Huffman Coding [6] , and Arithmetic Coding .

3) Lossless methods based on dictionary models: Models based on dictionary techniques use a code to replace a string of variable symbols [8]. The encoder processes the input pixels and runs the dictionary in order to find its correspondence. If the string is found, a pointer to the dictionary is used as code. Otherwise, the string processed is added to the dictionary. The most relevant methods are LZ77, LZ78, and LZW [6].

4) Lossless methods based on spatial domain models:

These methods use models in the space domain to remove the spatial redundancy existing in an image, either locally or globally. The coding process is done by means of statistical models of substitution. The most representative is the lossless JPEG standard. The model is based on a prediction algorithm of a pixel, once the previously processed pixels are known. The result of the prediction of a pixel is a value very close to zero or residual prediction error [8].

5) JPEG-LS standard: JPEG-LS is the new lossless compression method / near-lossless proposed standard for still images in continuous tone changes. This new standard method is based on the LOCO-I (Low Complexity Lossless).The term "near-lossless" refers to a standard way of accepting an insignificant loss of data not visible to the human eye.

6) Lossless methods based on wavelet transform:

The DCT based JPEG image compression will not have a significant effect on geometry by using ,"Blocking artifacts" and the edge effects are produced under the large compression ratio. A good solution to this problem is the use of "wavelet". So from the last two decades for "image Analysis and coding", DWT has become an important tool [5], [7].

Integer Wavelet Transform

The main drawback of the DWT is that the wavelet coefficients are real numbers. In this case efficient lossless coding is not possible using linear transforms. The lifting scheme (LS) presented by Sweldens allows an efficient implementation of the DWT. Another of its properties is that perfect reconstruction is ensured by the structure of the LS itself. This allows new transformations to be used. One such transformation is the integer wavelet transform (IWT) [5], [9] it is a basic modification of linear transforms, where each filter output is rounded to the nearest integer. IWT can be used to have a unified lossy and lossless codec. It is also of interest for hardware implementations, where the use of floating point is still a costly operation.

The wavelet Lifting Scheme is a method for decomposing wavelet transforms into a set of stages. The convolution-based 1-D DWT requires both a large number of arithmetic computations and a large memory for storage. Such features are not desirable for either high speed or low-power image processing applications. The main feature of the lifting-based wavelet transform is to break-up the high pass and the low pass wavelet filters into a sequence of smaller filters. The lifting scheme requires fewer computations compared to the convolution-based DWT. Therefore the computational complexity is reduced to almost a half of those needed with a convolution approach.

The main advantages of lifting scheme are as follows:

I) It allows a faster implementation of the wavelet transforms.

II) The lifting scheme allows a fully in-place calculation of the wavelet transform. In other words, no auxiliary memory is needed and the original signal (image) can be replaced with its wavelet transform.

III) With the lifting scheme, the inverse wavelet transform can immediately be found by undoing the operations of the forward transform. In practice, this comes down to simply reversing the order of the operations and changing each + into a - and vice versa.

Because of the superior energy compaction properties and correspondence with human visual system, wavelet compression methods have produced superior objective and subjective results. Since wavelet basis consists of functions with both short support (for high frequencies) and long support (for low frequencies), large smooth areas of an image may be represented with very few bits, and details are added where it is needed.

E. Lossless Coding Technique

1) Run Length Coding

Run length coding replaces data by a (length, value) pair, where “value” is the repeated value and “length” is the number of repetitions. This technique is especially successful in compressing bi-level images since the occurrence of a long run of a value is rare in ordinary gray-scale images. A solution to this is to decompose the gray-scale image into bit planes and compress every bit-plane separately [2],[4] ,[6].

2) *Lossless Predictive Coding*

Lossless predictive coding predicts the value of each pixel by using the values of its neighboring pixels. Therefore, every pixel is encoded with a prediction error rather than its original value. Typically, the errors are much smaller compared with the original value so that fewer bits are required to store them.

DPCM (differential pulse code modulation) is a predictive coding based lossless image compression method**.**

3) *Entropy Coding*

Entropy represents the minimum size of dataset necessary to convey a particular amount of information. Huffman coding, LZ (Lempel-Ziv) coding and arithmetic coding are the commonly used entropy coding schemes [2],[4],[6].

F. Performance Parameters

There are two performance parameters are used to measure the performance of the image compression algorithms.

One is PSNR (peak signal to noise ratio) and second is Mean square error (MSE).

Mean Square Error (MSE) is the cumulative difference between the compressed image and original image. Small amount of MSE reduce the error and improves image quality.

$$\text{MSE} = \frac{\sum_{M,N} [I_1(m,n)-I_2(m,n)]^2}{M*N}$$

PSNR is the measurement of the peak error between the compressed image and original image. The higher the PSNR contains better quality of image. To compute the PSNR first of all MSE (mean square error) is computed [1],[7].

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

R is the relative data redundancy of the representation with *b* bits

$$R = 1-\frac{1}{C}$$

Where C is Compression Ratio

Given as

$$C= \frac{Compressed\ Image}{Original\ Image}$$

III. CONCLUSION

Here different lossless Image Compression Techniques are discussed. Image Compression plays a significant role in reducing the transmission and storage cost. All the image compression techniques are useful in their related areas and every day new compression technique is developing which gives better compression ratio. In Lossless compression, the image is compressed and decompressed without any lose of information. Now a day a wavelet Lossless image Compression Technique is used and Integer Wavelet Transform is giving better compression ratio as like lossy compression without compromising the quality of image. Based on Different Technology conclude that the quality of the image can be measured by the important factor as like peak signal to noise ratio and mean square error and Compression ratio.

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