

Image Compression Techniques -A review

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Abstract—This paper gives an introduction about the area of image compression, its application with different type of approach use for compression purpose. Image compression involves the compression of unwanted or redundant data in image pixels. So reduced the problem of amount of data for space and the speed of transmission. A number of software has been developed for compression and many other functions. Compression basically deals with memory and minimizing the size in bytes of a graphics file without degrading the quality of the image to an acceptable level. During compression, the data is compressed so that it will occupy less space and become important when data is being transmitted over a network. Like a mobile phone for less bandwidth is needed and in the teleconferencing and other application. The objective of this paper is to provide a research overview of image compression techniques.

Key Words—Image Compression, Wavelet Transform, smoothness of image, quantization, Thresholding.

I. INTRODUCTION

A Image

An image is essentially a 2-D signal processed by the human visual system. The signals representing images are usually in analog form (1). However, for processing, storage and transmission by computer applications, they are converted from analog to digital form. A digital image is basically a 2-Dimensional array of pixels. An image is an array, or a matrix, of square pixels (picture elements) arranged in columns and rows. An image as defined in the “Real world” is considered to be a function of two real variables, for example, $a(x, y)$ with a as the amplitude (e.g. brightness) of the image at the real coordinate position (x, y) . Digitization of the spatial coordinates (x, y) is called image sampling. Amplitude digitization is called gray-level quantization.

B Image Compression

Image compression is minimizing the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level for problem of reducing the amount of data required to represent an image. Image compression reduces the number of bits required to represent the image, therefore the amount of memory required to store the data set is reduced. It also reduces the amount of time required to transmit a data set over a communication link at a given rate (2-5).

Image Compression addresses the problem of reducing the amount of data required to represent the digital image. Compression is achieved by the removal of one or more of three basic data redundancies:

- Coding redundancy, which is present when less than optimal (i.e. the smallest length) code words are used;
- Inter pixel redundancy, which results from correlations between the pixels of an image; &/or
- psycho visual redundancy which is due to data that is ignored by the human visual system (i.e. visually

non essential information). Huffman codes contain the smallest possible number of code symbols (e.g., bits) per source symbol (e.g., grey level value) subject to the constraint that the source symbols are coded one at a time. So, Huffman coding when combined with technique of reducing the image redundancies using discrete wavelet Transform (DWT) helps in compressing the image data to a very good extent.

The objective of compression is to reduce the number of bits as much as possible, while keeping the resolution and the visual quality of the reconstructed image as close to the original image as possible (5-10).

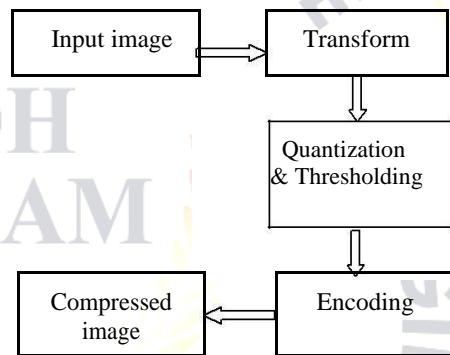


Fig.1-basic block structure of compression of image

C Need of Compression

Multimedia Data	Size/ duration	Bits/ Pixel	Uncompressed Size	Transmission bandwidth	Transmission Time
A page of text	11"x 8.5"	Varying resolution	4-8kb	32-4 Kb/Page	1.1-2.2 sec
Telephone quality	10 sec	8bps	80KB	4kb/sec	22.2 sec
Colour image	512x512	24bpp	578KB	.29 Mb. image	3 min 39 sec
Medical image	2048x1680	12bpp	5.1MB	41.3Mb/image	23 min 54 sec
Full-motion video	640x480,1 min(30 frames/second)	24bpp	1.6GB	221Mb/second	5 days 8 hrs

The image compression techniques are broadly classified in to two categories depending whether or not an exact replica of the original image could be reconstructed using the compressed image (11-13) .

These are:

1. Lossless technique
2. Lossy technique

1 Lossless compression technique

In lossless compression techniques, the original image can be perfectly recovered from the compressed (encoded) image. These are also called noiseless since they do not add noise to the signal (image). It is also known as entropy coding since it use statistics/decomposition techniques to eliminate/minimize redundancy. Lossless compression is used only for a few applications with stringent requirements such as medical imaging.

B Huffman Encoding

This is a general technique for coding symbols based on their statistical occurrence frequencies

Following techniques are included in lossless compression:

1. Run length encoding
2. Huffman encoding
3. LZW coding
4. Area coding

2 Lossy compression technique

Lossy schemes provide much higher compression ratios than lossless schemes. Lossy schemes are widely used since the quality of the reconstructed images is adequate for most applications .By this scheme, the decompressed image is not identical to the original image, but reasonably close to it.

Major performance considerations of a lossy compression scheme include:

1. Compression ratio
2. Signal - to - noise ratio
3. Speed of encoding & decoding.

Lossy compression techniques includes following schemes:

1. Transformation coding
2. Vector quantization
3. Fractal coding
4. Block Truncation Coding
5. Sub-band coding

LOSSLESS COMPRESSION TECHNIQUES

A Run Length Encoding

This is a very simple compression method used for sequential data. This technique replaces sequences of identical symbols (pixels), called runs by shorter symbols. The run length code for a gray scale image is represented by a sequence $\{V_i , R_i \}$ where V_i is the intensity of pixel and R_i refers to the number of consecutive pixels with the intensity V_i as shown in the figure. If both V_i and R_i are represented by one byte, this span of 12 pixels is coded using eight bytes yielding a compression ratio of 1: 5

82	82	82	82	82	89	89	89	89	90	90
{82,5}		{89,4}		{90,2}		entropy				

Fig 2: Run Length Encoding

(probabilities). The pixels in the image are treated as symbols. The symbols that 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. Most image coding standards use lossy techniques in the earlier stages of compression and use Huffman coding as the final step.

C LZW Coding

LZW (Lempel- Ziv –Welch) is a dictionary based coding. Dictionary based coding can be static or dynamic. In static dictionary coding, dictionary is fixed during the encoding and decoding processes. In dynamic dictionary coding, the dictionary is updated on fly. LZW is widely used in computer industry and is implemented as compress command on UNIX.

D Area Coding

Area coding is an enhanced form of run length coding, reflecting the two dimensional character of images. This is a significant advance over the other lossless methods. For coding an image it does not make too much sense to interpret it as a sequential stream, as it is in fact an array of sequences, building up a two dimensional object. The algorithms for area coding try to find rectangular regions with the same characteristics. These regions are coded in a descriptive form as an element with two points and a certain structure. This type of coding can be highly effective but it bears the problem of a nonlinear method, which cannot be implemented in hardware. Therefore, the performance in terms of compression time is not competitive, although the compression ratio is.

LOSSY COMPRESSION TECHNIQUES

A Transformation Coding

In this coding scheme, transforms such as DFT (Discrete Fourier Transform) and DCT (Discrete Cosine Transform) are used to change the pixels in the original image into frequency domain coefficients (called transform coefficients). These coefficients have several desirable properties. One is the energy compaction property that results in most of the energy of the original data being concentrated in only a few of the significant transform coefficients. This is the basis of achieving the compression. Only those few significant coefficients are selected and the remaining is discarded. The selected coefficients are considered for further quantization and encoding. DCT coding has been the most common approach to transform coding. It is also adopted in the JPEG image compression standard (13-17).

B Vector Quantization

The basic idea in this technique is to develop a dictionary of fixed-size vectors, called code vectors. A vector is usually a block of pixel values. A given image is then partitioned in to non-overlapping blocks (vectors) called image vectors. Then for each in the dictionary is determined and its index in the dictionary is used as the encoding of the original image vector. Thus, each image is represented by a sequence of indices that can be further entropy coded.

C

Fractal Coding

The essential idea here is to decompose the image into segments by using standard image processing techniques such as colour separation, edge detection, and spectrum and texture analysis. Then each segment is looked up in a library of fractals. The library actually contains codes called iterated function system (IFS) codes, which are compact sets of numbers. Using a systematic procedure, a set of codes for a given image are determined, such that when the IFS codes are applied to a suitable set of image blocks yield an image that is a very close approximation of the original. This scheme is highly effective for compressing images that have good regularity and self-similarity.

D Block truncation coding

In this scheme, the image is divided into non overlapping blocks of pixels. For each block, threshold and reconstruction values are determined. The threshold is usually the mean of the pixel values in the block. Then a bitmap of the block is derived by replacing all pixels whose values are greater than or equal (less than) to the threshold by a 1 (0). Then for each segment (group of 1s and 0s) in the bitmap, the reconstruction value is determined. This is the average of the values of the corresponding pixels in the original block.

E Sub band coding

In this scheme, the image is analyzed to produce the components containing frequencies in well-defined bands, the sub bands. Subsequently, quantization and coding is applied to each of the bands. The advantage of this scheme is that the quantization and coding well suited for each of the sub band scan be designed separately.

II DISCRETE WAVELET TRANSFORM

Wavelet function is defined over a finite interval and having an average value zero. The basic idea of the wavelet is to represent any arbitrary function (t) as a superposition of a set of such wavelet of basic functions (17-23).

These basis functions or baby wavelets are obtained from a single prototype wavelet called the mother wavelet, by dilations or contractions (scaling) and translations (shifts).

$$\psi_{ab}(t) = \frac{1}{\sqrt{a}} \psi\left(\frac{t-b}{a}\right) \tag{1}$$

Where, a is the scaling parameter and, b is the shifting parameter.

Wavelets Transform is a method to analysis a image in time and frequency domain, it is effective for the analysis of image. Wavelet transform give the multi resolution decomposition of image [18]. There is the basic concept of multi resolution: (i) sub-band coding; (ii) vector space and pyramid structure coding. DWT decompose an image at several n levels in different frequency bands. Each level decomposes an image into approximation coefficients (low frequency band of processing) and detail coefficients (high frequency band of processing 1), and the result is down sampled by 2 shown in Fig. 3[19, 20].

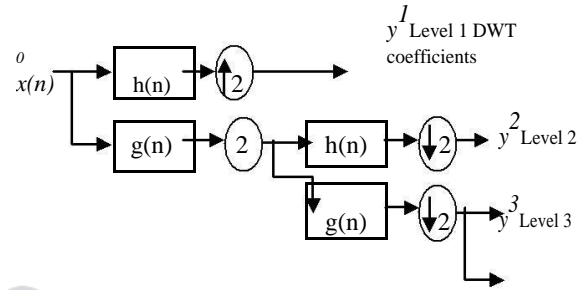


Fig.3 Filter bank representation of DWT decomposition:

At each step of DWT decomposition, there are two outputs: scaling coefficients $x^{j+1}(n)$ and the wavelet coefficients $y^{j+1}(n)$. These coefficients are:

$$x^{j+1}(n) = \sum_{i=1}^{2n} h(2n-i) x^j(i)$$

and

$$y^{j+1}(n) = \sum_{i=1}^{2n} g(2n-i) x^j(i)$$

Where, the original image is represented by $x^0(n)$ and j shows the scaling number. Here $g(n)$ and $h(n)$ represent the low pass and high pass filter, respectively. The output of scaling function is input of next level of decomposition, known as approximation coefficients.

In order to reconstruct the original image, at each level of reconstruction, approximation components and the detailed components are up by 2 and the detailed components are up sampled by 2, and then convolved which is shown in Fig.4.

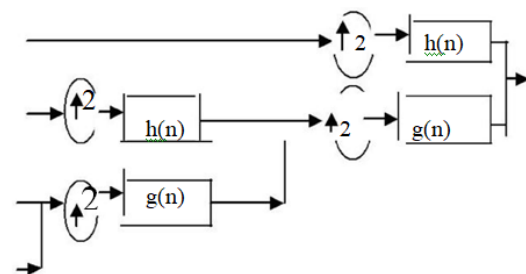


Fig.4. IDWT filter banks

III METHODOLOGY

The image compression is achieved using wavelet transformation and its process is based on uniform quantization and entropy encoding. The basic methodology for image compression is shown in Fig. 5.

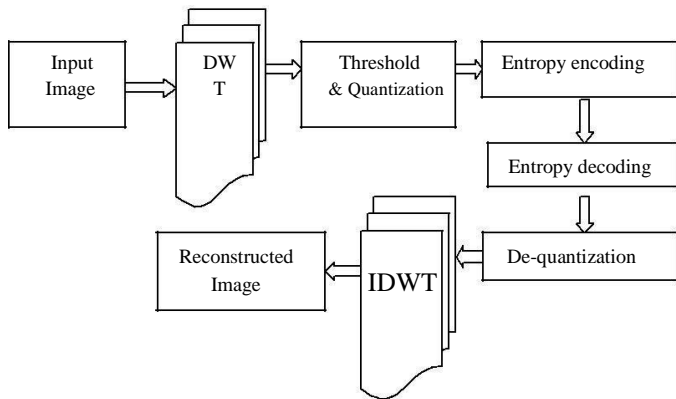


Fig. 5.Compression methodology for image compression.

The algorithm of image compression is performing in three stages: (i) DWT decomposition, (ii) Threshold & Quantization, (iii) Entropy encoding. After DWT decomposition of the image, their wavelet coefficients are selected on the basis of energy packing efficiency of each sub-band. Then, apply a Thresholding (level or global), which suggested that a fixed percentage of wavelet coefficients should be zero Further, uniform Quantizer is applied in these coefficients. The actual compression is achieved at this stage and then compression achieved based on the entropy encoding techniques (Huffman). Finally compressor system gives the compressed data value of image.

A THRESHOLDING

The next step after decomposition of image is Thresholding, after decomposing of the image a threshold is applied to coefficients for each level from 1 to N[5,18,21]. So many of the wavelet coefficients are zero or near to zero so due to Thresholding near to zero coefficients are equal to zero. By applying a hard Thresholding the coefficient below the level is zero so produce a many consecutive zero” s which can stored in much less space and transmission speed is up, and in the case of global Thresholding the value are set manually, this value are chosen from the range (0...Cmax) where Cmax is maximum coefficient in the decomposition.

B QUANTIZATION

Next step after the Thresholding stage is uniform quantization; aim of this step is to decreases the information which found in the wavelet coefficients in such a way so no error is formed. We quantize the wavelet coefficients using uniform quantization, the computation of step size depend on three parameters [3, 5, 17] are:

- Maximum value, M_{max} in the matrix
- Minimum value, M_{min} in the matrix
- Number of quantization level, L

Once these parameters are found, then step size, Δ

$$\Delta = \left(\frac{M_{max} - M_{min}}{L} \right) \quad (2)$$

Then, the input is divided in to L+1 level with equal interval size ranging from M_{min} to M_{max} to plot quantization table. When quantization step is done, then quantization value is fed to the next stage of compression. Three parameters defined above are stored in the file because to create the quantization table during reconstruction step for de-quantization [1].

C HUFFMAN ENCODING

In quantization process, the quantized data contains some unused full data, means repeated data, it is wastage of space. To overcome this problem, Huffman encoding [5,1] is exploited. In Huffman encoding, the probabilities of occurrence of the symbols in a image are computed. These symbols indices in the quantization table. Then these symbols are arranged according to the probabilities of occurrence in descending order and build a binary tree and codeword table.

To reconstruct the image, we will reverse the three processes which perform in this paper (Wavelet Transform, Quantization, and Huffman Coding) (23-27).

IV CONCLUSION

This paper presents overview of various types of image compression techniques. There are basically two types of compression techniques. One is Lossless Compression and other is Lossy Compression Technique. Comparing the performance of compression technique is difficult unless identical data sets and performance measures are used. Some of these techniques are obtained good for certain applications like security technologies. Some techniques perform well for certain classes of data and poorly for others. Transform techniques also found its applications as image compression

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