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A review of Image Compression

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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 humanvisual system. The signals representing images are usually inanalog form (1). However, for processing, storage andtransmission by computer applications, they are convertedfrom 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-levelquantization.

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 t for problem of reducing the amount of data required to represent a 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 requiredtorepresent the digital image. Compression is achieved by the removal of one or more ofthreebasic data redundancies:

(1) Coding redundancy, which is present when less thanoptimal (i.e.the smallest length) code words are used;

(2) Interpixel redundancy, whichresults fromcorrelations between the pixels of an image; &/or

(3) psycho visual redundancywhich is due todata that is ignored by the human visual system (i.e. visually nonessentialinformation).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 sourcesymbols are coded one at a time. So, Huffman coding when combined with technique ofreducing the image redundancies using discrete wavelet Transform (DWT) helps incompressing the image data to a very good extent.

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

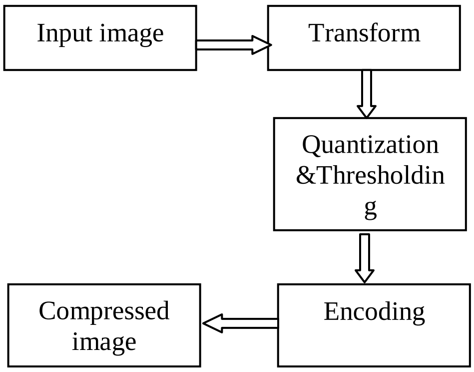

Fig.1-basic block structure of compression of image

C Need Of Compression

Multime-dia data	**Size/ duration**	**Bits/ Pixel**	**Uncompressed Size**	**Transmis s-ion bandwidth**	**Transmiss-ion 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
Color 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/sec)	24bpp	1.6GB	221Mb/sec	5 days 8 hrs

The image compression techniques are broadly classified intotwo categories depending whether or not an exact replica ofthe original image could be reconstructed using thecompressed image(11-13) .

These are:

1. Lossless technique
2. Lossy technique

1 Lossless compression technique

In lossless compression techniques, the original image can beperfectly recovered from the compressed (encoded) image.These are also called noiseless since they do not add noise tothe signal (image).It is also known as entropy coding since ituse statistics/decomposition techniques to eliminate/minimizeredundancy. Lossless compression is used only for a fewapplications with stringent requirements such as medicalimaging.

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 thanlossless schemes. Lossy schemes are widely used since thequality of the reconstructed images is adequate for mostapplications .By this scheme, the decompressed image is notidentical 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 sequentialdata. It is very useful in case of repetitive data. This techniquereplaces sequences of identical symbols (pixels) ,called runsby shorter symbols. The run length code for a gray scaleimage is represented by a sequence { Vi , Ri } where Vi is theintensity of pixel and Ri refers to the number of consecutivepixels with the intensity Vi as shown in the figure. If both Viand Ri are represented by one byte, this span of 12 pixels iscoded using eight bytes yielding a compression ratio of 1: 5

Fig-2: Run –Length Encoding

B Huffman Encoding

This is a general technique for coding symbols based on theirstatistical occurrence frequencies (probabilities). The pixels inthe image are treated as symbols. The symbols that occurmore frequently are assigned a smaller number of bits, whilethe symbols that occur less frequently are assigned arelatively larger number of bits. Huffman code is a prefixcode. This means that the (binary) code of any symbol is notthe prefix of the code of any other symbol. Most image coding standards use lossy techniques in the earlier stages ofcompression 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 staticdictionary coding, dictionary is fixed during the encoding anddecoding processes. In dynamic dictionary coding, thedictionary is updated on fly. LZW is widely used in computerindustry 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 asignificant advance over the other lossless methods. Forcoding an image it does not make too much sense to interpretit as a sequential stream, as it is in fact an array of sequences,building up a two dimensional object. The algorithms for areacoding try to find rectangular regions with the samecharacteristics. These regions are coded in a descriptive formas an element with two points and a certain structure. Thistype of coding can be highly effective but it bears the problemof a nonlinear method, which cannot be implemented inhardware. Therefore, the performance in terms ofcompression time is not competitive, although thecompression ratio is.

LOSSY COMPRESSION TECHNIQUES

A Transformation Coding

In this coding scheme, transforms such as DFT (DiscreteFourier Transform) and DCT (Discrete Cosine Transform) areused to change the pixels in the original image into frequencydomain coefficients (called transform coefficients).Thesecoefficients have several desirable properties. One is theenergy compaction property that results in most of the energyof the original data being concentrated in only a few of thesignificant transform coefficients. This is the basis ofachieving the compression. Only those few significantcoefficients are selected and the remaining is discarded.Theselected coefficients are considered for further quantizationand

82	82	82	82	82	89	89	89	89	90	90

{82,5}	{89,4}	{90.2}

entropy

encoding. DCT coding has been the mostcommon approach to transform coding.It is also adopted inthe JPEG image compression standard (13-17).

B Vector Quantization

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

C Fractal Coding

The essential idea here is to decompose the image into segmentsby using standard image processing techniques such ascolor separation, edge detection, and spectrum and textureanalysis. Then each segment is looked up in a library offractals. The library actually contains codes called iteratedfunction system (IFS) codes, which are compact sets ofnumbers. Using a systematic procedure, a set of codes for agiven image are determined, such that when the IFS codes areapplied to a suitable set of image blocks yield an image that isa very close approximation of the original. This scheme ishighly effective for compressing images that have goodregularity and self-similarity.

D Block truncation coding

In this scheme, the image is divided into non overlappingblocks of pixels. For each block, threshold and reconstructionvalues are determined. The threshold is usually the mean ofthe pixel values in the block. Then a bitmap of the block isderived by replacing all pixels whose values are greater thanor equal (less than) to the threshold by a 1 (0). Then for eachsegment (group of 1s and 0s) in the bitmap, the reconstructionvalue is determined. This is the average of the values of thecorresponding pixels in the original block.

E Sub band coding

In this scheme, the image is analyzed to produce thecomponents containing frequencies in well-defined bands, thesub bands. Subsequently, quantization and coding is appliedto each of the bands. The advantage of this scheme is that thequantization and coding well suited for each of the sub bandscan 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).

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

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 (iii) pyramid structure coding. DWT decompose a image at several *n* levels in different frequency bands. Each level decomposes a image into approximation coefficients (low frequency band of processing) and detail coefficients (high frequency band of processing l), and the result is down sampled by 2 shown in Fig. 3[19, 20].

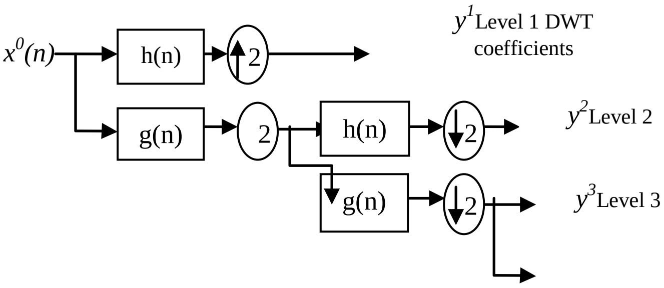

Fig.3 Filter bank representation of DWT decomposition:

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:

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

and

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

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.

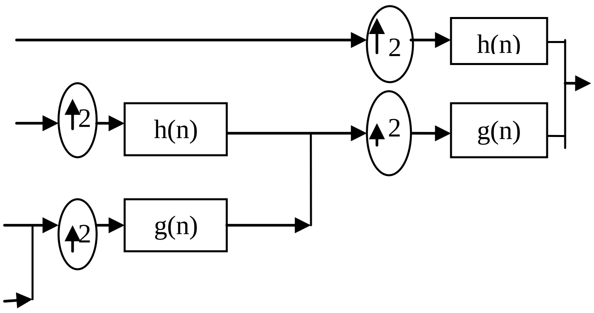

Fig.4. IDWT filter banks

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.

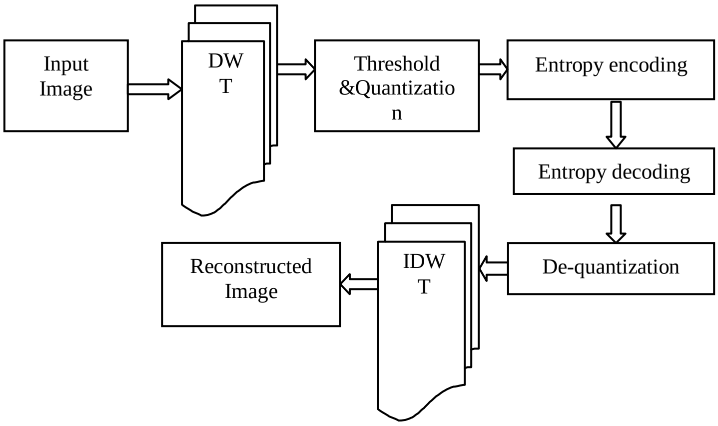

Fig. 5.Compression methodology for image compression.

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 1to 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 aping 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……..C_{max}) where $C_{max}$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:

(i) Maximum value, M_{max}in the matrix
(ii) Minimum value, M_{min} in the matrix
(iii) Number of quantization level, L

Once these parameters are found, then step size, Δ

$$\Delta = \left(M_{max} - M_{min} \big/ L \right) \qquad (2)$$

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 compressiontechniques. There are basically two types of compressiontechniques. One is Lossless Compression and other is Lossy Compression Technique. Comparing the performance ofcompression technique is difficult unless identical data setsand performance measures are used. Some of thesetechniques are obtained good for certain applications likesecurity technologies. Some techniques perform well forcertain classes of data and poorly for others. Transform techniques also found its applications as imagecompression

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