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A Review of Data Compression Technique

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ABSTRACT

With the growth of technology and the entrance into the Digital Age, the world has found itself amid a vast amount of information. Dealing with such enormous amount of information can often present difficulties. Digital information must be stored and retrieved in an efficient manner, in order for it to be put to practical use. Compression is one way to deal with this problem. Images require substantial storage and transmission resources, thus image compression is advantageous to reduce these requirements. Image compression is a key technology in transmission and storage of digital images because of vast data associated with them. This paper addresses about various image compression techniques. There are two types of image compression: lossless and lossy.
***Keywords*:-** Image Compression, JPEG, Discrete wavelet Transform.

I. INTRODUCTION

Image compression is important for many applications that involve huge data storage, transmission and retrieval such as for multimedia, documents, videoconferencing, and medical imaging. Uncompressed images require considerable storage capacity and transmission bandwidth. The objective of image compression technique is to reduce redundancy of the image data in order to be able to store or transmit data in an efficient form. This results in the reduction of file size and allows more images to be stored in a given amount of disk or memory space.

II. IMAGE COMPRESSION

Image compression addresses the problem of reducing the amount of data required to represent a digital image. It is a process intended to yield a compact representation of an image, thereby reducing the image storage/ transmission requirements. Compression is achieved by the removal of one or more of the three basic data redundancies:

- Coding Redundancy
- Interpixel Redundancy
- Psychovisual Redundancy

Coding redundancy is present when less than optimal code words are used. Interpixel redundancy results from correlations between the pixels of an image. Psychovisual redundancy is due to data that is ignored by the human visual system (i.e. visually non essential information).Image compression techniques reduce the number of bits required to represent an image by taking advantage of these redundancies. An inverse process called decompression (decoding) is applied to the compressed data to get the reconstructed image. 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.

Image compression may be lossy or lossless. Lossless compression is preferred for archival purposes and often for medical imaging, technical drawings, clip art, or comics. Lossy compression methods, especially when used at low bit rates, introduce compression artifacts. Lossy methods are especially suitable for natural images such as photographs in applications where minor (sometimes imperceptible) loss of fidelity is acceptable to achieve a substantial reduction in bit rate. The lossy compression that produces imperceptible differences may be called visually lossless.

A. Lossless Compression

Lossless compression algorithms reduce file size with no loss in image quality. When the file is saved it is compressed, when it is decompressed (opened) the original data is retrieved. The file data is only temporarily 'thrown away', so that the file can be transferred.

This type of compression can be applied not just to graphics but to any kind of computer data such as spreadsheets, text documents and software applications. If you need to send files as an email attachment, then you may be best to compress it first. sLossless image compression is particularly useful in image archiving as in the storage of legal or medical records Methods for lossless image compression includes: Entropy coding, Huffman coding, Bit-plane coding, Run-length coding and LZW (Lempel Ziv Welch) coding.

The advantage of this is that it maintains quality the main disadvantage is it doesn't reduce the file size as much as lossy compression.

B. Lossy Compression

Lossy compression also looks for 'redundant' pixel information, however, it permanently discards it. This means that when the file is decompressed the original data isn't retrieved. In lossy compression, the original signal cannot be exactly reconstructed from the compressed data. The reason is that, much of the detail in an image can be discarded without greatly changing the appearance of the image. Lossy compression isn't used for data such as text based documents and software, since they need to keep all their information Lossy image compressions are useful in applications such as broadcast television, videoconferencing, and facsimile transmission, in which a certain amount of error is an acceptable trade-off for increased compression performance. Methods for lossy compression include: Fractal compression, Transform coding, Fourier-related transform, DCT (Discrete Cosine Transform) and Wavelet transform.

C. Benefits of Compression

• It provides a potential cost savings associated with sending less data over switched telephone network where cost of call is really usually based upon its duration. Mapper Quantizes Symbol Coder Symbol Decoder Inverse Mapper

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

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

• It also provides a level of security against illicit monitoring.

III. IMAGE COMPRESSION TECHNIQUES

A. Lossless Compression Techniques

1) Run length encoding

2) Entropy encoding

3) Huffman encoding

4) Arithmetic coding

5) LZW coding

1) Run Length Encoding: Rle is used in lossless data compression. This is a very simple compression method used for sequential data. It is very useful in case of repetitive data. This technique replaces sequences of identical symbols (pixels), called runs by shorter symbols. Runs is sequences in which the same data value occurs in many consecutive data elements are stored as a single data value and count, rather than as the original run. The run length code for a gray scale 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. If both Vi and Ri are represented by one byte, this span of 12 pixels is coded using eight bytes yielding a compression ratio of 1: 5.

RLE may also be used to refer to an early graphics file format. It does not work well at all on continuous-tone images such as photographs, although JPEG uses it quite effectively on the coefficients that remain after transforming and quantizing image blocks. This technique is based on the repetition of colors in an image. If you read the image from the top left, reading a row of pixels at a time, you often get runs of pixels of the same color. If there are 3 or more pixels in a row, storing the number in the run and the color is more efficient.

2) Entropy encoding: An entropy encoding is a coding scheme that involves assigning codes to symbols so as to match code lengths with the probabilities of the symbols. Typically, entropy encoders are used to compress data by replacing symbols represented by equal-length codes with symbols represented by codes proportional to the negative logarithm of the probability. Therefore, the most common symbols use the shortest codes.

3) Huffman coding: This is a general technique for coding symbols based on their statistical occurrence frequencies (probabilities)..The Huffman’s algorithm is generating minimum redundancy codes compared to other algorithms. The Huffman coding has effectively used in text, image, video compression, and conferencing system such as, JPEG, MPEG-2, MPEG-4, and H.263 etc. The pixels in the image are treated as symbols.

The Huffman coding technique collects unique symbols from the source image and calculates its probability value for each symbol and sorts the symbols based on its probability value. Further, from the lowest probability value symbol to the highest probability value symbol, two symbols combined at a time to form a binary tree. Moreover, allocates zero to the left node and one to the right node starting from the root of the tree. To obtain Huffman code for a particular symbol, all zero and one collected from the root to that particular node in the same order.

Most image coding standards use lossy techniques in the earlier stages of compression and use Huffman coding as the final step.

4) Arithmetic Encoding: AC is the most powerful technique for statics lossless encoding that has attracted much attention in the recent years. It provides more flexibility and better efficiency than the celebrated Huffman coding does. The aim of AC is to define a method that provides code words with an ideal length. Like for every other entropy coder, it is required to know the probability for the appearance of the individual symbols.

AC is the most efficient method to code symbols according to the probability of their occurrence. The average code length is very close to the possible minimum given by information theory.

The AC assigns an interval to each symbol whose size reflects the probability for the appearance of this symbol. The code word of a symbol is an arbitrary rational number belonging to the corresponding interval.

5) LZW Coding: LZW (Lempel- Ziv – Welch) is a dictionary based coding.LZW algorithm is working based on the occurrence multiplicity of character sequences in the string to be encoded. Its

Principle consists in substituting patterns with an index code, by progressively building a dictionary. The dictionary is initialized with the 256 values of the ASCII table. The file to be compressed is split into strings of bytes (thus monochrome images –coded on 1 bit – this compression is not very effective), each of these strings is compared with the dictionary and is added, if not found there.

In encoding process the algorithm goes over the stream of information, coding it; if a string is never smaller than the longest word in the dictionary then it s transmitted.

In decoding process, the algorithm rebuilds the dictionary in the opposite direction; it thus does not need to be stored. 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.

B. Lossy Coding Techniques

1) *Transform coding*
2) *DCT*
3) *Fractal Compression*
4) *DWT*

1) Transform Coding: Transform coding algorithm usually start by partitioning the original image into sub images (blocks) of small size (usually 8 x 8). For each block the transform coefficients are calculated, effectively converting the original 8 x 8 array of

pixel values into an array of coefficients closer to the top-left corner usually contain most of the information needed to quantize and encode the image with little perceptual distortion .The resulting coefficients are then quantized and the output of the quantizer is used by a symbol encoding technique(s) to produce the output bit stream representing the encoded image.

At the decoder's side, the reverse process takes place, with the obvious difference that the ""dequantization" stage will only generate an approximated version of the original coefficient values; in other words, whatever loss is introduced by the quantizer in the encoder stage is not reversible.

2) DCT: 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.

The DCT process is applied on blocks of 8 * 8 or 16 * 16 pixels, which will convert into series of coefficients, which define spectral composition of the block. The Transformer transforms the input data into a format to reduce interpixel redundancies in the input image.

Transform coding techniques use a reversible, linear mathematical transform to map the pixel values onto a set of coefficients, which are then quantized and encoded. The key factor behind the success of transform-based coding schemes is that many of the resulting coefficients for most natural images have small magnitudes and can be quantized without causing significant distortion in the decoded image. DCT Attempts to decorrelate the image data after decorrelation each transform coefficient can be encoded without dropping off compression efficiency.

3) Fractal Compression: The fractal compression technique relies on the fact that in certain images, parts of the image resemble other parts of the same image. Fractal algorithms convert these parts, or more precisely, geometric shapes into mathematical data called "fractal codes" which are used to recreate the encoded image. Once an image has been converted into fractal code its relationship to a specific resolution has been lost; it becomes resolution independent.

The image can be recreated to fill any screen size without the introduction of image artifacts or loss of sharpness that occurs in pixel-based compression schemes

4) Dwt: The DWT represents an image as a sum of wavelet functions, known as wavelets, with different location and scale.

IV. DISCRET WAVELET TRANSFORM (DWT)

The DWT represents the image data into a set of high pass (detail) and low pass (approximate) coefficients.

The image is first divided into blocks of 32×32. Each block is then passed through the two filters: the first level decomposition is performed to decompose the input data into an approximation and detail coefficients. After obtaining the transformed matrix, the detail and approximate coefficients are separated as LL, HL, LH, and HH coefficients. All the coefficients are discarded except the LL coefficients that are transformed into the second level. The coefficients are then passed through a constant scaling factor to achieve the desired compression ratio.

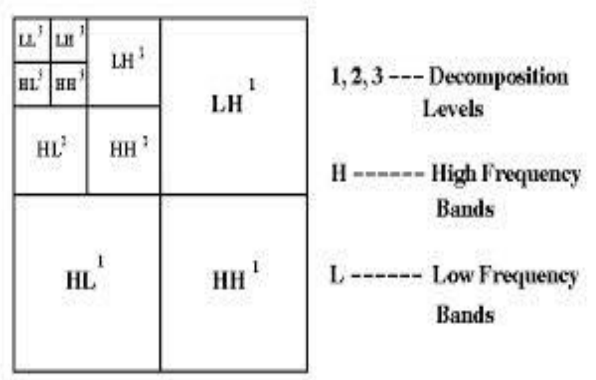

Fig. 1 Example of wavelet decomposition

Compression Steps:

The steps needed to compress an image are as follows:

- Digitize the source image into a signal s, which is a string of numbers.
- Decompose the signal into a sequence of wavelet coefficients w.
- Use thresholding to modify the wavelet coefficients from w to another sequence w'.
- Use quantization to convert w' to a sequence q.
- Apply entropy coding to compress q into a sequence e.

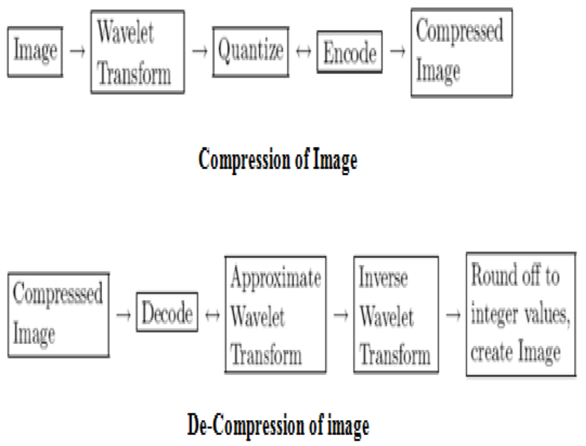

Fig. 2 Example of Image Compression and decompression

A. Digitization

The first step in the wavelet compression process is to digitize the image. The digitized image can be characterized by its intensity levels, or scales of gray which range from 0 (black) to 255 (white), and its resolution, or how many pixels per square inch. Each of the bits involved in creating an image takes up both time and money, so a tradeoff must be made.

B. Thresholding

In certain signals, many of the wavelet coefficients are close or equal to zero. Through a method called thresholding, these coefficients may be modified so that the sequence of wavelet coefficients contains long strings of zeros. Through a type of compression known as entropy coding, these long strings may be stored and sent electronically in much less space.

There are different types of thresholding. In hard thresholding, a tolerance is selected. Any wavelet whose absolute value falls below the tolerance is set to zero with the goal to introduce many zeros without losing a great amount of detail. There is not a straightforward easy way to choose the threshold, although the larger the threshold that is chosen the more error that is introduced into the process. Another type of thresholding is soft thresholding. Once again a tolerance, h, is selected. If the absolute value of an entry is less than the tolerance, than that entry is set to zero. All other entries, d, are replaced with sign(d)||d| - h|.

Soft thresholding can be thought of as a translation of the signal toward zero by the amount h. A third type of thresholding is quantile thresholding. In this method a percentage p of entries to be eliminated are selected. The smallest (in absolute value) p percent of entries are set to zero.

C. Entropy Coding

Wavelets and thresholding help process the signal, but up until this point, no compression has yet occurred. One method to compress the data is Huffman entropy coding. With this method, and integer sequence, q, is changed into a shorter sequence, e, with the numbers in e being 8 bit integers.

The conversion is made by an entropy coding table. Strings of zeros are coded by the numbers 1 through 100, 105, and 106, while the non-zero integers in q are coded by 101 through 104 and 107 through 254. In Huffman entropy coding, the idea is to use two or three numbers for coding, with the first being a signal that a large number or long zero sequence is coming. Entropy coding is designed so that the numbers that are expected to appear the most often in q, need the least amount of space in e.

D. Quantization

The fourth step of the process, known as quantization, converts a sequence of floating numbers w' to a sequence of integers q. The simplest form is to round to the nearest integer. Another option is to multiply each number in w' by a constant k, and then round to the nearest integer.

Quantization is called lossy because it introduces error into the process, since the conversion of w' to q is not a one-to-one function.

V. CONCLUSION AND FUTYRE SCOPE

This paper presents 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. By studying and discussing all the techniques we find lossy compression techniques provides high compression ratio than lossless compression scheme.

Lossy compression is used for more compression ratio and Lossless compression is used when the original image and reconstructed image are to be identical.. Wavelet can be effectively used for this purpose. Our future work involves improving image quality by increasing PSNR value and lowering MSE value.

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