International Journal of Engineering Research and General Science Volume 3, Issue 2, March-April, 2015
ISSN 2091-2730

Image Compression Techniques: Lossy and Lossless

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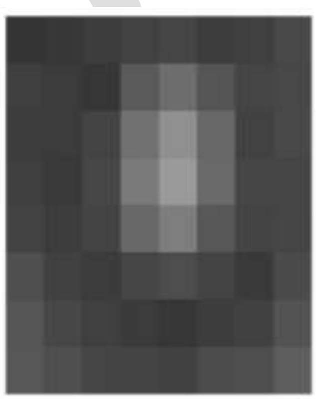
Abstract— Digital image compression technology has emerged from the need for fast communication and 'live' processing of digital image information over the internet. Time has been passed and a lot of techniques now are available that reduce the compression ratio, and increase usability of fast computation, but as we are bound to certain limits, there are lots of innovative ways that are yet to overcome these limits. Today's world is very dependent on digital media storage, that's why it requires more efficient algorithms for image or data compression. Due to reserved bandwidth and capacity, images need be compressed and soft-encoded before further using it in transmission process. This paper points out Lossy as well as Lossless compression techniques as they are used in fields of image processing.

Keywords— DCT, DFT, Data Compression, Encryption, Decryption, Lossless Compression, Lossy Compression

INTRODUCTION

Digital Image Processing having some useful technologies and concepts which are famous for its commercial use also. The digital multimedia is so popular nowadays that each second nearly 26,396 Giga Bytes of data is transferred over the world, in which nearly 1,873 Giga Bytes are only Images. Needless to say, it requires a large amount of space to store the contents. Besides, the requirement of resolution is much higher than before. The art of representing the information in a compact form rather than its original or uncompressed form is compression [1]. The digital cameras, as compared to conventional film cameras produce instant images, which can be viewed without the delay of a second. The compression helps to reduce the cost of storage and to transmit images more efficiently. The compression techniques are mainly lossy compression techniques and lossless compression techniques. In the first one, 2D transforms that can be inverted are used. Lossy methods are especially suited for natural photographs where minor loss is acceptable. On the other hand, Lossless compression is preferred medical imaging, technical drawings, clip arts where every pixel information is important.

An image is essentially a 2-D signal processed by our brain. At the most times, the information in an image is analog in nature. But, they are converted from analog to digital form for purposes. A digital image is a 2-D array of pixels. If **f(x, y)** represents an image, **x** and **y** represents spatial co-ordinates of each pixel. This image array is converted as matrix form to manipulate in digital processor.



$$\begin{bmatrix} 52 & 55 & 61 & 66 & 70 & 61 & 64 & 73 \\ 63 & 59 & 55 & 90 & 109 & 85 & 69 & 72 \\ 62 & 59 & 68 & 113 & 144 & 104 & 66 & 73 \\ 63 & 58 & 71 & 122 & 154 & 106 & 70 & 69 \\ 67 & 61 & 68 & 104 & 126 & 88 & 68 & 70 \\ 79 & 65 & 60 & 70 & 77 & 68 & 58 & 75 \\ 85 & 71 & 64 & 59 & 55 & 61 & 65 & 83 \\ 87 & 79 & 69 & 68 & 65 & 76 & 78 & 94 \end{bmatrix}$$

Figure 1: Image as a 2D Matrix

IMAGE COMPRESSION

Image compression is a process which on implementation gives output which is often smaller in size but looks similar to the original. The block diagram of image coding system is shown in below:

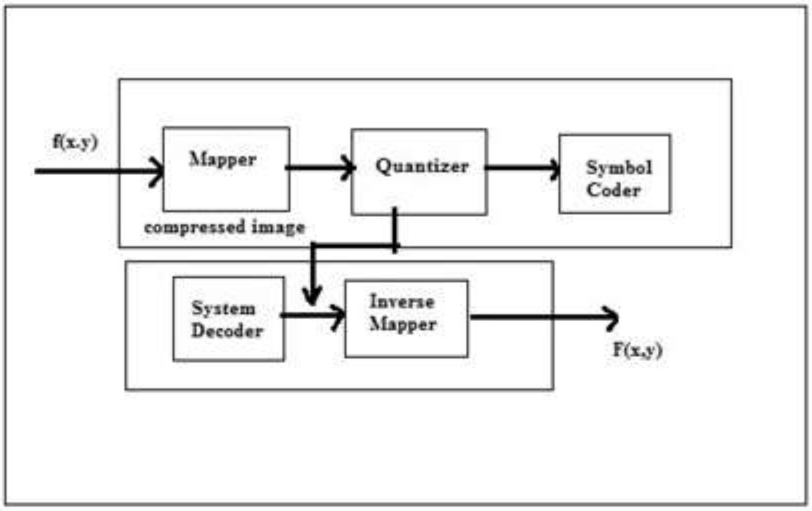


Figure 2: Image Compression Technique

The camera catches the reflected light from the surface of the objects placed at specific distance, and the received light illumination will be converted into 3 primary color components R, G and B. By coding algorithms, these three primary color components are processed.

Image compression involves a process to give out a compact representation of an image, in turn reducing the image storage and transmission requirements. Compression is achieved by the removing one of the following redundancy:

1. Coding
2. Inter-pixel
3. Perceptual

Coding redundancy emerges when the codes assigned to a set of events such as the pixel values like position, intensity of illumination, of an image have not been selected to take full advantage of the probabilities of the events [2].

It is only possible to represent an image having compressed resolution by taking these redundancies in consideration. Here, decoding is done to get the original image. The soul objective of compression is to reduce the number of bits to much possible extent, while keeping the resolution and the quality of the reconstructed image as close to the original image as possible.

Image compression systems are consists of two blocks: an encoder and a decoder. Image in the form of 2-D matrix denoted as f(x, y) is fed into the encoder. If we let p and q denote the number of units that carry information (both actual) in the original and pre-processed images respectively, the compression that we get is calculated through the compression ratio, $C_R = p/q$ [3]. As shown in **Fig.2**, the encoder reduces all three redundancies of input image. Firstly, the Image mapper translates the input image into a format suitable to reduce inter-pixel loop-holes. The second stage, quantizer reduces the mapper's output accuracy in accordance with a predefined values. In final stage, a symbol decoder generates a random code for quantizer output and maps the output in accordance with the given code. These blocks when operates in reverse order, the inverse operations of the encoder's symbol coder and mapper block are performed. This does not apply to the quantization process, and is not included in the process.

ADVANTAGES OF IMAGE COMPRESSION

The benefits of image compression can be listed as follows:

1. Cost for transmitting an image as data reduces at much extent as cost depends upon duration for which data is being transmitted.
2. It saves computing power as execution of image transmission takes very less time if the size is lesser.
3. It reduces the transmission errors since fewer bits are transferred.
4. Secure level of transmission is possible due to encoding and compressing the image.

TYPES OF IMAGE COMPRESSION

The image compression techniques are broadly classified into two categories [4]. These are:

1. Lossy techniques
2. Lossless techniques

Lossy Compression Techniques:

Lossy compression methods have larger compression ratios as compared to the lossless compression techniques. Lossy methods are used for most applications. By this the output image that is reconstructed image is not exact copy but somehow resembles it at larger portion.

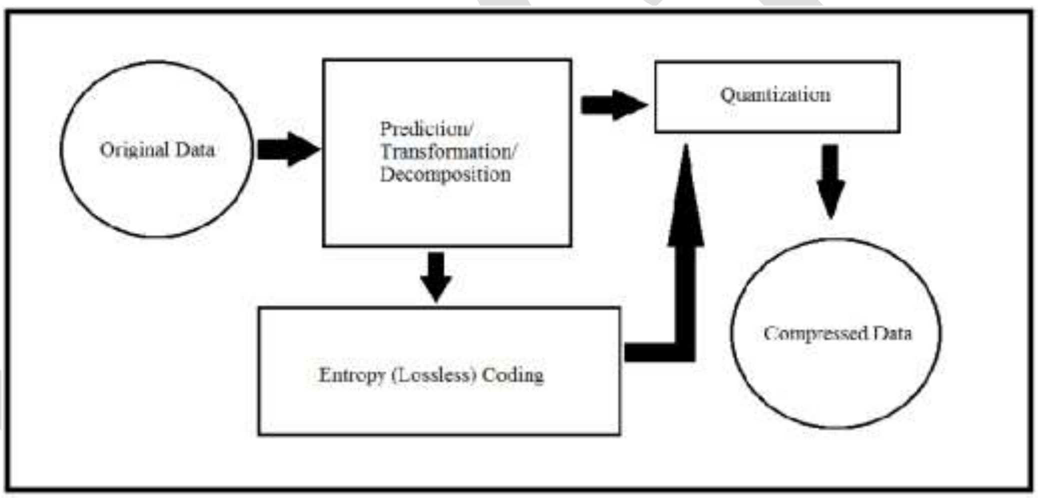


Figure 3: Lossy Image Compression

As shown in Fig.3, this prediction – transformation – decomposition process is completely reversible. There is loss of information due to process of quantization. The entropy coding after the quantizing, is lossless. When decoder has input data, entropy decoding is applied to compressed signal values to get the quantized signal values. Then, de-quantization is used on it and the image is recovered which resembles to the original [5].

Lossy compression methods include some basic consideration (performance wise):

1. Speed of encoding and decoding
2. Compression ratio
3. SNR ratio.

Lossy compression includes following methods:

1. Block truncation coding
2. Code Vector quantization
3. Fractal coding
4. Transform coding
5. Sub-band coding

Techniques

Block Truncation Coding

In this, image is divided into blocks like we have in fractals. The window of N by N of an image is considered as a block. The mean value of all values of that window consisting a certain number of pixel. The threshold is normally the mean value of the pixel values in the vector. Then a bitmap of that vector is generated by replacing all pixels having values are greater than or equal to the threshold by a 1. Then for each segment in the bitmap, a value is determined which is the average of the values of the corresponding pixels in the original code vector.

Code Vector Quantization

The basic idea in Vector Quantization is to create a dictionary of vectors of constant size, called code vectors. Values of pixels composed the blocks called as code vector. A given image is then parted into non-recurring vectors called image vectors. Dictionary is made out this information and it is indexed. Further, it is used for encoding the original image. Thus, every image is then entropy coded with the help of these indices.

Fractal Compression

The basic thing behind this coding is to divide image into segments by using standard points like color difference, edges, frequency and texture. It is obvious that parts of an image and other parts of the same image are usually resembling. Here, there is a dictionary which is used as a look up table called as fractal segments. The library contains codes which are compact sets of numbers. Doing an algorithm operation, fractals are operated and image is encoded. This scheme is far more effective for compressing images that are natural and textured.

Transform Coding

In this coding, transforms like Discrete Fourier Transform (DFT) and Discrete Cosine Transform (DCT), Discrete Sine Transform are used to alter the pixel specifications from spatial domain into frequency domain. One is the energy compaction property, some few coefficients only have the energy of original image signal that can be used to reproduce itself. Only those few significant coefficients are considered and the remaining is discarded. These coefficients are given for quantization and encoding. DCT coding has been the most commonly used in transformation of image data.

Subband Coding

In this scheme, quantization and coding is applied to each of the analyzed sub-bands from the frequency components bands. This coding is very useful because quantization and coding is more accurately applied to the sub-bands.

Lossless Compression Techniques

It is also known as entropy coding as it uses decomposition techniques to minimize loopholes. The original image can be perfectly recovered from the compressed image, in lossless compression techniques. These do not add noise to the signal. It is also known as entropy coding as it uses decomposition techniques to minimize redundancy.

Following techniques are included in lossless compression [6]:

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

Techniques

Huffman Coding

As shown in Fig. 4, this is a general technique for coding symbols using their statistical occurrence frequencies.

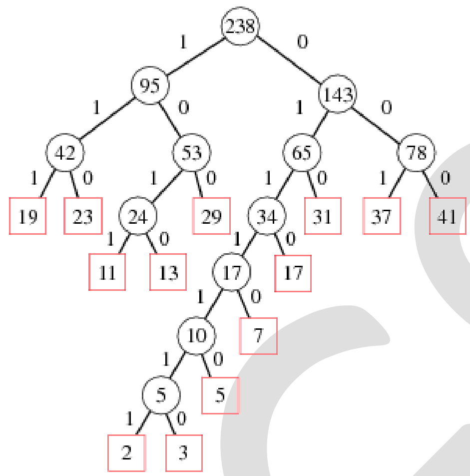


Figure 4: Huffman Coding

The pixels in the given image are assigned some specific numbers. The pixel having lesser occurrences will be given higher number of bits and the pixel with higher frequency occurrences will get relatively lesser number of bits. It is a prefix code. No two symbols in an image can have exactly same binary set of numbers. [7] In the commercial arena, most standards uses lossy or noisy methods of compression in early stages and in the final stage, the Huffman's code.

Run Length Encoding

If the data is sequencial and repetative Run Length Coding comes in as a simple method.

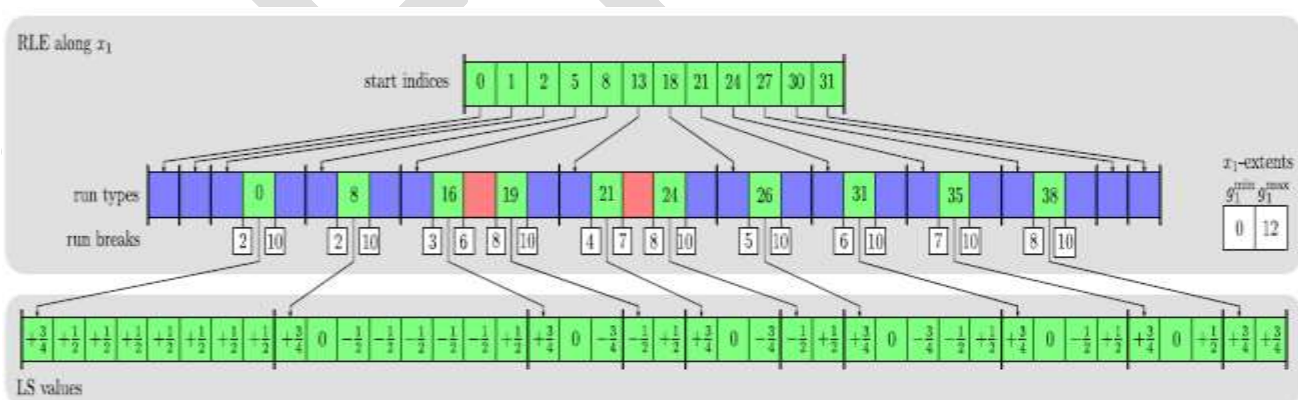


Figure 5: Run-Length Coding

In this, sequencial symbols are replaced by what is called 'runs by shorter symbols'. [8] 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. If both V_i and R_i are represented by one byte, this total 12 pixels which are generated using only 8 bytes constitues compression ratio of 1:5.

Area Coding

This is advanced form of earlier coding technique. It is nothing but a array that build up when it is easy to get 2D object of itself. [9] Here, same characteristics has to be chosen for the 2D blocks of pixels. These blocks or windows are coded in a form stating their spatial coordinates and a structure. The only drawback of this technique is that it uses non-linear method which is unapplicable in hardware.

LZW Coding

LZW (Lempel-Ziv–Welch) is also a dictionary based coding. As it uses dictionary based coding, LZW has been greatly affecting digital world. Sequence used in here can be fixed or updated as soon as it is needed.

CONCLUSION

This paper points out different basic image compression techniques. As there are two types of compression methods namely Lossy and Lossless techniques, the usability and efficiency of respective techniques are different. Lossy methods of compression produce loss of information at the cost of reduction in size, whereas lossless methods do not produce any loss in information. But they have certain limitations so their commercial importance is less. Lossy compression is used where losing some information is tolerable such as audio, still images. But lossless compression is must for text files of bank records, text articles. Losing a slight information from an image in some fields like medical is not at all tolerable. Thus, it is necessary to enhance lossless compression techniques over lossy compression methods.

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