IMAGE COMPRESSION TECHNIQUES

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ABSTRACT

"A picture is worth more than thousand words" is a common saying. What an image can communicate cannot be expressed through words. Images play an indispensable role in representing vital information and needs to be saved for further use or can be transmitted over a medium. In order to have efficient utilization of disk space and transmission rate, images need to be compressed. Image compression is the technique of reducing the file size of an image without compromising with the image quality at an acceptable level. Image compression is been used from a long time and many algorithms have been devised. In this paper addresses the area of image compression as it is applicable to various fields of image processing.

Keywords: *Data Compression, Lossless Compression, Lossy Compression*

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1. INTRODUCTION

1.1 IMAGE

A digital image is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels. Image compression is recognized as an "enabling technology". It provides a major role in many important and diverse applications, including tele-video conferencing, remote sensing, document and medical imaging, FAX and the control of remotely piloted vehicles in military space and hazardous waste management applications.

1.2 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:

1. Coding Redundancy
2. Interpixel Redundancy
3. 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 systems are composed of two distinct structural blocks: an encoder and a decoder.

STEPS INVOLVED IN COMPRESSING IMAGE:

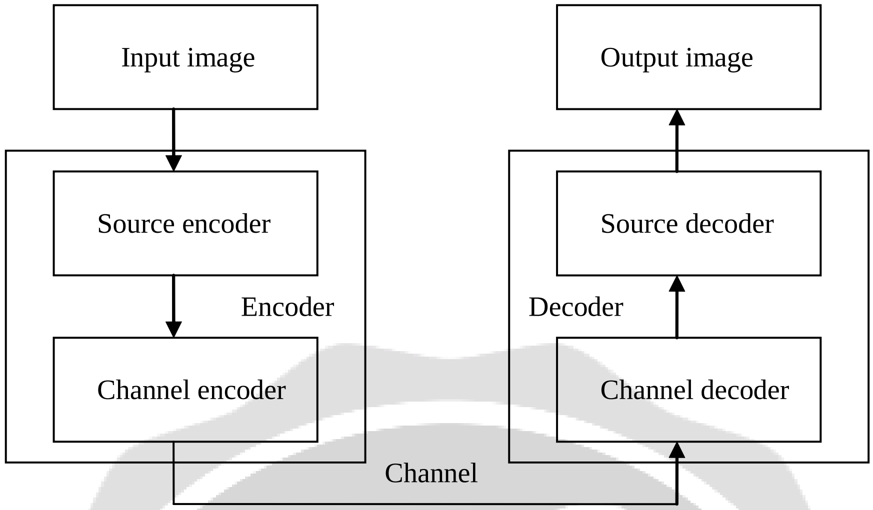


Image f(x,y) is fed into the encoder, which creates a set of symbols form the input data and uses them to represent the image. If we let n1 and n2 denote the number of information carrying units (usually bits) in the original and encoded images respectively, the relative data redundancy R_D of the first data set can be defined as

$$R_{D = 1-1/} C_R$$

Where $C_{R.}$ commonly called the compression Ratio

$$C_R = n1 /n2$$

As shown in the figure, the encoder is responsible for reducing the coding, interpixel and psychovisual redundancies of input image.

2. IMAGE COMPRESSION TECHNIQUES

The image compression techniques are broadly classified into two categories depending whether or not an exact replica of the original image could be reconstructed using the compressed image.
These are:

1. Lossless technique
2. Lossy technique

2. 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.
Following techniques are included in lossless compression:

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

2.2 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:

- Compression ratio
- Signal - to – noise ratio

- Speed of encoding & decoding.

Lossy compression techniques includes following schemes:

- Lossy predictive coding
- Transform coding
- Wavelet coding

2.3 LOSSLESS COMPRESSION TECHNIQUES

2.3.1 Run Length Encoding

Run-length encoding (RLE) is a very simple form of data compression in which runs of data (that 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. This is most useful on data that contains many such runs: for example, relatively simple graphic images such as icons, line drawings, and animations.

Let us take a hypothetical single scan line, with B representing a black pixel and W representing white:

WWWWWWWWWWWWBWWWWWWWWWWWWBBBWWWWWWWWWWWWWWWWWWWWWWWWBWWWWWWWWWWWWWW

If we apply the run-length encoding (RLE) data compression algorithm to the above hypothetical scan line, we get the following: 12W1B12W3B24W1B14W.This is a general technique for coding symbols based on their statistical occurrence frequencies (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.

2.3.2 Huffman Coding

Dr. David A. Huffman proposed Huffman Coding in 1952. This method used for the construction of minimum redundancy code. Huffman code is a technique for compressing data. Huffman's greedy algorithm looks at the occurrence of each character and it as a binary string in an optimal way. Huffman coding is a form of statistical coding which attempts to reduce the amount of bits required to represent a string of symbols. The algorithm accomplishes its goals by allowing symbols to vary in length. Shorter codes are assigned to the most frequently used symbols, and longer codes to the symbols which appear less frequently in the string (that's where the statistical part comes in). Code word lengths are no longer fixed like ASCII .Code word lengths vary and will be shorter for the more frequently used characters.

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.

FIGURE
Huffman code assignment procedure.

Original source			Source reduction							
Sym.	Prob.	Code	1		2		3		4	
a_2	0.4	1	0.4	1	0.4	1	0.4	1	0.6	0
a_6	0.3	00	0.3	00	0.3	00	0.3	00	0.4	1
a_1	0.1	011	0.1	011	0.2	010	0.3	01		
a_4	0.1	0100	0.1	0100	0.1	011				
a_3	0.06	01010	0.1	0101						
a_5	0.04	01011								

Example:

010100111100 = $a_3\ a_1\ a_2\ a_2\ a_6$

2.3.3 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. LZW compression has been integrated into a variety of mainstream imaging rule formats, including the graphic interchange format(GIF),tagged image file format(TIFF), and the portable document format(PDF).

LZW coding process, a “codebook or dictionary” containing the source symbols to be coded is constructed. For 8-bit monochrome images, the first 256 words of the dictionary are assigned to the gray values 0, 1, 2…255.

2.3.4 Area Coding

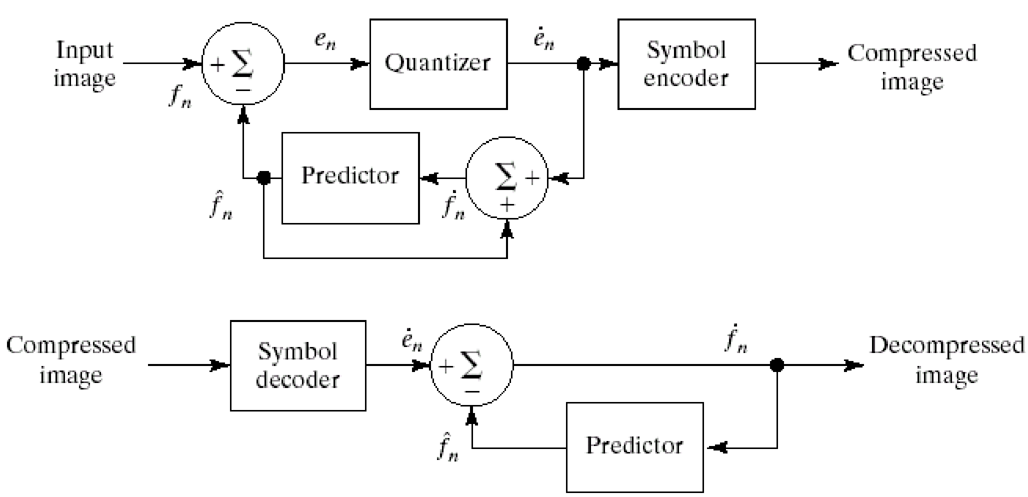
Area coding is an enhanced form of run length coding, reflecting the two dimensional character of images. This is a significant advance over the other lossless methods. For coding an image it does not make too much sense to interpret it as a sequential stream, as it is in fact an array of sequences, 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.

2.4 LOSSY COMPRESSION TECHNIQUES

2.4.1 Predictive Coding

Transmit the difference between estimate of future sample & the sample itself.

- Delta modulation
- DPCM
- Adaptive predictive coding
- Differential frame coding

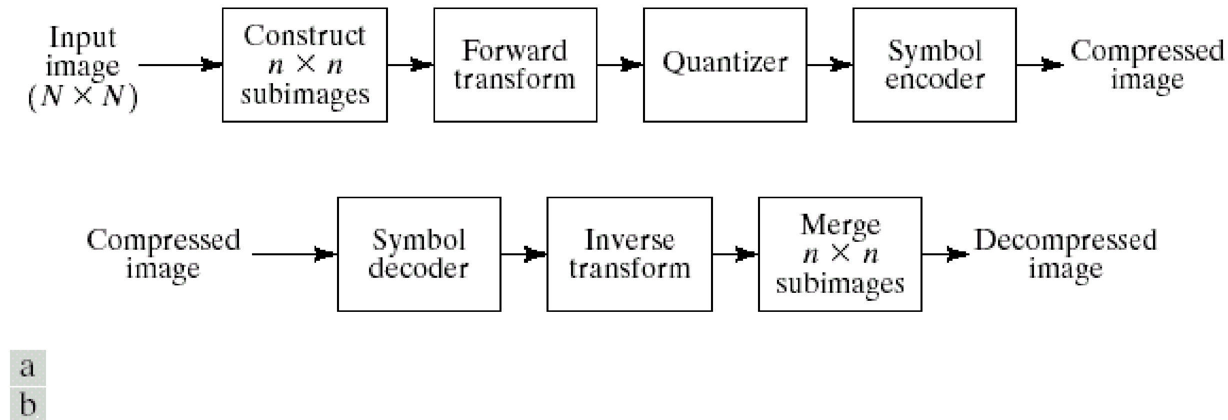


a
b

FIGURE A lossy predictive coding model: (a) encoder and (b) decoder.

2.4.2. Transform 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 entropy encoding. DCT coding has been the most common approach to transform coding. It is also adopted in the JPEG image compression standard.



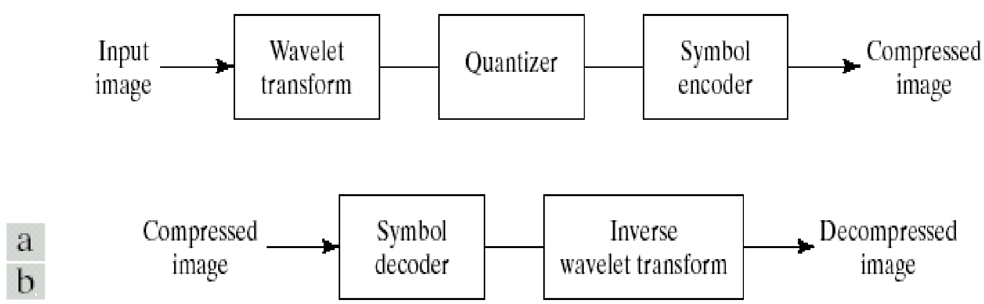
A transform coding system: (a) encoder; (b) decoder.

The goal of the transformation process is to decorrelate the pixels of each sub-image, or to pack as much information as possible into the smallest number of transform coefficients such as

1. Dividing the image into sub-images of size 8x8
2. Representing each sub-image using one of the transforms
3. Truncating 50% of the resulting coefficients
4. Taking the inverse Transform of the truncated coefficien**ts**

2.4.3. Wavelet Coding

Wavelet transforms have received significant attention in many fields, such as mathematics, digital signal and image processing, because of their ability to represent and analyze data. The basic idea is to choose the update filters according to some decision criterion which depends on the local characteristics of the input signal. The following diagram depicts the wavelet encoding system.



wavelet coding system: (a) encoder; (b) decoder.

CONCLUSION

This paper study aims to point out various image compression techniques, viz., Lossless and Lossy techniques. It provides a major role in many important and diverse applications, including tele-video conferencing, remote sensing, document and medical imaging, FAX and the control of remotely piloted vehicles in military space and hazardous waste management applications. The image compression is also used 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.

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