Image Compression Study Using Lossless and Lossy Techniques

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Abstract

Image compression is a type of data compression in which the real image is encoded with a few bits. The goal of picture compression is to reduce the redundancy and irrelevance of image data so that it may be recorded or sent in a useful format. As a result, picture reduction reduces network transmission time and increases transmission speed. "A picture is worth a thousand words," as the adage goes. Words are incapable of expressing what an image can say. Images are essential for representing important information and must be retained for later use or conveyed across a channel. Images must be compressed in order to make the most use of storage space and transmission speed. Picture compression is a technique for lowering the file size of an image while maintaining acceptable image quality. For a long time, image compression has been employed, and numerous techniques have been developed. The topic of picture compression as it applies to many domains of image processing is discussed in this study.

Keywords: *Image Compression; Data; Encoding.*

I. INTRODUCTION

Image compression is a sort of data/image compression application in which the fundamental image is encoded with a restricted number of bits. The main goal of picture compression is to reduce the irrelevance and duplication of image data so that it may be preserved or transmitted in a better format. Image compression is the process of reducing the amount of an image's data while keeping the needed information. The primary goal of image compression is to display a picture in a minimal number of bits while maintaining the necessary amount of information inside the image. Compression solutions for large quantities of data, such as photos, are continuously evolving. Due to the rapid advancement of technology, a great amount of picture data must be controlled in order to properly retain such photos. The adoption of efficient approaches usually results in image compression.

There are certain algorithms that are used to produce these sorts of compression in various ways, such as lossless and lossy. The image that requires compression is a grayscale image with pixel values ranging from 0 to 255. Compression is the process of reducing the amount of data required to display the content of an image, file, or video without sacrificing the real data's quality. It also reduces the number of bits required to preserve and transmit digital media. Compressing anything means that there is a piece of data whose size must be reduced. JPEG is the ideal choice for digital images in this case. The Joint Photographic Expert Group (JPEG) system, which is based on the Discrete Cosine Transform (DCT), has been a widely used compression method.

Image compression is one of several well-known image processing methods. This technology may be implemented in a variety of ways and is critical for the efficient storage and transmission of pictures. Image compression aims to reduce redundancy in picture data by recording or sending only a small number of samples, and by doing so, a decent reconstruction for the real image that corresponds to human visual perception may be achieved.

The main goal of this study is to compress pictures by reducing the number of bits required to display them on a per-pixel basis, as well as to reduce the time required to transmit images and reconstruct them using the Huffman encoding technique.

II STEPS INVOLVED IN COMPRESSING IMAGE

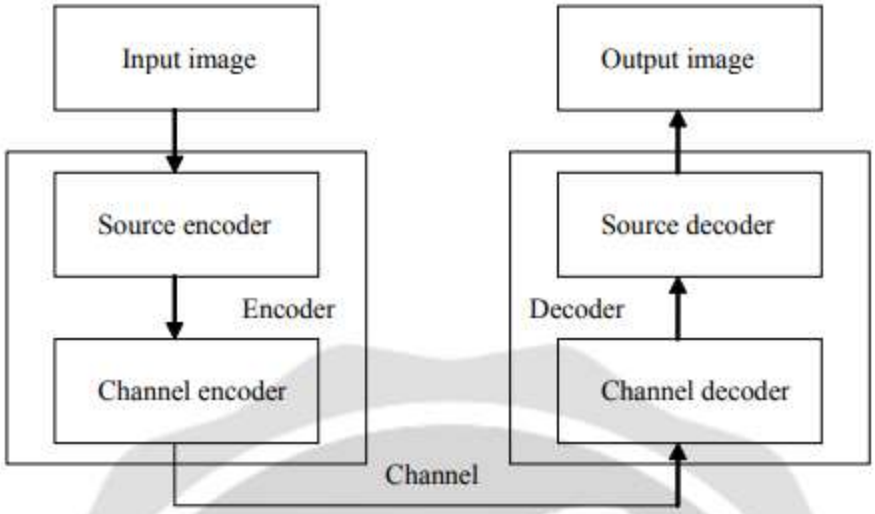

Figure 1: Steps involved in compressing image

The encoder receives the picture f(x,y) and generates a collection of symbols from the input data to represent the image. The relative data redundancy R_D of the first data set may be described as where n1 and n2 are the number of information carrying units (typically bits) in the original and encoded pictures, respectively.

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

Where C_R. commonly called the compression Ratio

C_R = n1 /n2

The encoder is responsible for decreasing the coding, inter pixel, and psycho visual redundancy of the input image, as indicated in the figure.

III. IMAGE COMPRESSION TECHNIQUES

Picture compression techniques are divided into two categories based on whether or not the compressed image may be used to recreate an identical reproduction of the original image. These are the following:

1. Lossless technique
2. Lossy technique

3.1 Lossless compression technique

The original picture may be perfectly retrieved from the compressed (encoded) image using lossless compression techniques. They're also known as noiseless since they don't contribute any noise to the signal (image). Because it employs statistics/decomposition techniques to eliminate/minimize duplication, it's also known as entropy coding. Only a few applications with demanding criteria, such as medical imaging, employ lossless compression. Lossless compression employs the following techniques:

- **Run length encoding**

Run-length encoding (RLE) is a basic method of data compression in which data runs (that is, sequences in which the same data value appears in several consecutive data elements) are saved as a single data value and count rather than the original run. This is especially handy when dealing with data that comprises a large number of such runs, such as icons, line drawings, and animations. Consider the following single scan line, where B represents a black pixel and W represents white:

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.

- **Huffman encoding**

In 1952, Dr. David A. Huffman proposed Huffman Coding. This strategy is used to create code with the bare minimum of redundancy. Huffman coding is a data compression method. Huffman's greedy approach optimizes the number of times each character appears in a binary string. Huffman coding is a type of statistical coding that tries to cut down on the number of bits needed to represent a string of symbols. The algorithm achieves its objectives by enabling symbols to have different lengths. The most commonly used symbols are given shorter codes, while the symbols that appear less frequently in the string are given longer codes (here is where the statistical component comes in). The lengths of code words are no longer predetermined, as they are in ASCII. The lengths of code words vary, with the more commonly used letters being shorter.

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				

Figure 2: A Huffman encoding assignment procedure

A prefix code is the Huffman code. This indicates that any symbol's (binary) code is not the prefix of any other symbol's code. Lossy compression techniques are used in the early stages of picture compression, with Huffman coding being the last step.

Example: 010100111100 = a_3 a_1 a_2 a_2 a_6

- **LZW coding**

Lempel-Ziv-Welch (LZW) is a dictionary-based coding system. The use of dictionaries for coding can be either static or dynamic. The dictionary is fixed during the encoding and decoding stages in static dictionary coding. The dictionary is updated on the fly in dynamic dictionary coding. LZW is a commonly used compression algorithm in the computer industry, and it is implemented as a UNIX compress command. The visual interchange format (GIF), the tagged image file format (TIFF), and the portable document format (PDF) all have LZW compression built in (PDF).

A "codebook or dictionary" containing the source symbols to be coded is created throughout the LZW coding process. The grey values 0, 1, 2...255 are allocated to the first 256 words in the dictionary for 8-bit monochrome pictures.

- **Area coding**

Area coding is a more advanced version of run length coding that takes into account the two-dimensional nature of pictures. This is a big step forward from the previous lossless approaches. It makes little sense to code a picture as a sequential stream because it is actually an array of sequences that make up a two-dimensional entity. Area coding methods look for rectangular areas with similar properties. These areas are coded in a descriptive manner as a two-pointed element with a specific structure. This sort of coding is very efficient, but it has the disadvantage of being a nonlinear approach that cannot be implemented in hardware.

3.2 Lossy compression technique

Lossy compression ratios are substantially greater than lossless compression ratios. Because the quality of the reconstructed pictures is acceptable for most applications, lossy techniques are extensively utilised. The decompressed image isn't exactly the same as the original image, but it's near enough. The following are some of the most important performance factors for a lossy compression scheme:

- **Predictive Coding**

Transmit the difference between the sample's estimate and the actual sample.

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

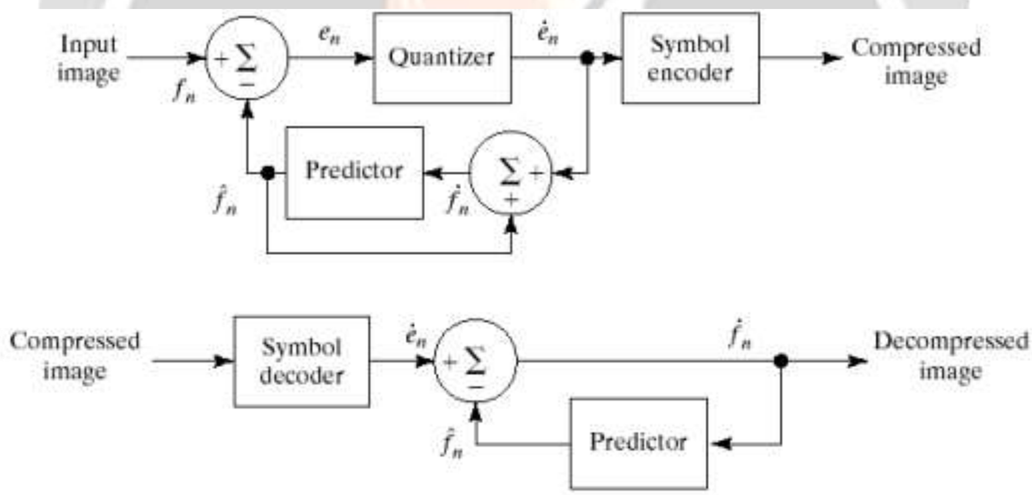

Figure 3: A Lossy predictive coding model

- **Transform Coding**

DFT (Discrete Fourier Transform) and DCT (Discrete Cosine Transform) transformations are employed in this coding method to convert the pixels in the source picture into frequency domain coefficients (called transform coefficients). These coefficients have a number of appealing characteristics. One is the energy compaction property, which causes the majority of the original data's energy to be condensed in only a few significant transform coefficients. This is the foundation for compressing the data. Only the most significant coefficients are chosen, with the rest being deleted. For further quantization and entropy encoding, the specified coefficients are examined. The most prevalent method of transform coding has been DCT coding. The JPEG image compression standard uses it as well.

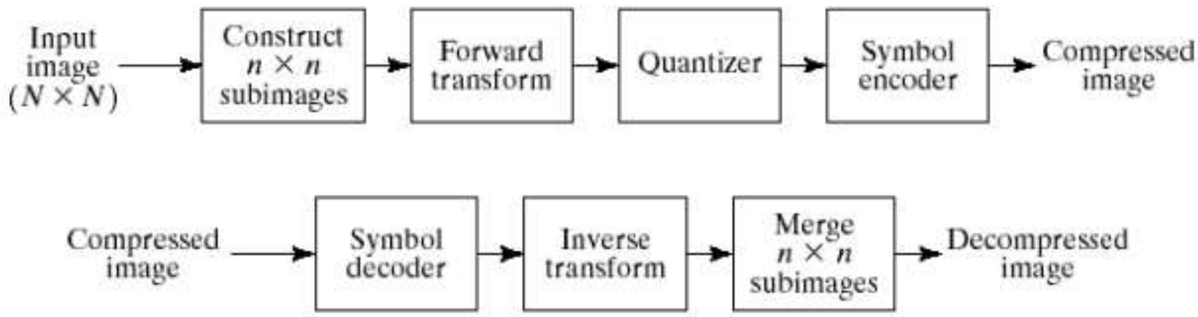

Figure 4: A transform coding model

The purpose of the transformation process is to de-correlate each sub-pixels, image's or to cram as much information as possible into the fewest amount of transform coefficients feasible, 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 coefficients

- **Wavelet Coding**

Because of its capacity to represent and analyse data, wavelet transformations have gotten a lot of interest in domains including mathematics, digital signal processing, and image processing. The main concept is to select update filters based on a decision criterion that is dependent on the input signal's local characteristics. The wavelet encoding scheme is depicted in the diagram below.

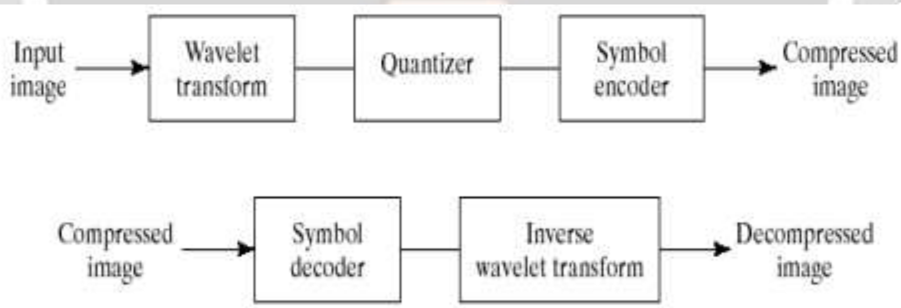

Figure 5: A Wavelet Coding model

IV. CONCLUSION

This paper describes a novel picture compression approach that use Wavelet-based Image Coding in conjunction with the Huffman encoder. This approach combines the zero tree architecture of wavelet-coefficients with the Huffman encoder at the decomposition level of 8, resulting in a greater compression ratio and improved PSNR. The goal of this work is to highlight several picture compression techniques, such as Lossless and Lossy approaches. Tele-video conferencing, remote sensing, document and medical imaging, FAX, and the operation of remotely piloted vehicles in military space and hazardous waste management applications are just a few of the numerous applications it serves. Image compression is also used to minimise the number of bits as much as feasible while maintaining the reconstructed image's resolution and visual quality as near to the original as possible.

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