A Study of Image Compression Techniques

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Abstract- An image is an artifact that depicts or records visual perception. Images are important documents today; to work with them in some applications there is need to be compressed the image. Compression is more or less it depends on our aim of the application. Image compression plays a very important role in the transmission and storage of image data as a result of and storage limitations. The main aim of image compression is to represent an image in the fewest number of bits without losing the essential information content within an original image. This paper addresses about various image compression techniques. On the basis of analyzing the various image compression techniques this paper presents a survey of existing research papers. In this paper we analyze different types of existing method of image compression.
Keywords: Image Compression, DCT, DWT, OCR, Run length Encoding.

1. Introduction

Image compression is the application of data compression on digital images. Image compression is the technique through which we can reduce amount of data required to represent a digital image. It is also used for reducing the redundancy that is nothing but avoiding the duplicate data, which will helpful to increase storage and transmission process performance. In image compression, we do not only concentrate on reducing size but also concentrate on doing it without losing quality and information of image.

Many applications need large number of images which can be stored on disk for solving problems. This storing space of image is important, because less memory space means less time required processing the image. Hence image compression is need that reduces the amount of data required to represent a digital image. Image compression is the process of encoding an image to reduce the number of bytes required to store or transmit the image.
Image compression system requires two components:

a) Encoding System that converts original image into compressed image
b) Decoding System that converts compressed image into digital image which is more identical to original image.

Image compression, consist of three main steps: Transform, quantizing and coding, as illustrated in figure 1below.

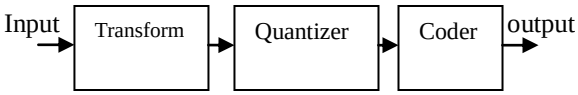

Figure 1: The three steps of digital image compression system

Image compression consists of two transform techniques which are based on frequency.
First is Discrete Cosine Transform (DCT) and second is Discrete Wavelet Transform (DWT). Both techniques have its' own pros and cons. DWT gives better compression ratio without losing more information of image but it need more processing power. While DCT is fast, it can be quickly calculated but it has blocks artifacts means loss of some information. It provides a review about various image compression techniques.

Image Compression

Image compression addresses the problem of reducing the amount of information 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. Every image will have redundant data. Redundancy means the duplication of data in the image. Either it may be repeating pixel across the image or pattern, which is repeated more frequently in the image. The image compression occurs by taking benefit of redundant information of in the image. Reduction of redundancy provides helps to achieve a saving of storage space of an image. Image

compression is achieved when one or more of these redundancies are reduced or eliminated. In image compression, three basic data redundancies can be identified and exploited. Compression is achieved by the removal of one or more of the three basic data redundancies.

- **Inter Pixel Redundancy**

In image neighbouring pixels are not statistically independent. It is due to the correlation between the neighboring pixels of an image. This type of redundancy is called Inter-pixel redundancy. This type of redundancy is sometime also called spatial redundancy. This redundancy can be explored in several ways, one of which is by predicting a pixel value based on the values of its neighboring pixels. In order to do so, the original 2-D array of pixels is usually mapped into a different format, e.g., an array of differences between adjacent pixels. If the original image pixels can be reconstructed from the transformed data set the mapping is said to be reversible.

- **Coding Redundancy**

Consists in using variable length code words selected as to match the statistics of the original source, in this case, the image itself or a processed version of its pixel values. This type of coding is always reversible and usually implemented using lookup tables (LUTs). Examples of image coding schemes that explore coding redundancy are the Huffman codes and the arithmetic coding technique.

- **Psycho Visual Redundancy**

Many experiments on the psycho physical aspects of human vision have proven that the human eye does not respond with equal sensitivity to all incoming visual information; some pieces of information are more important than others. Most of the image coding algorithms in use today exploit this type of redundancy, such as the Discrete Cosine Transform (DCT) based algorithm at the heart of the JPEG encoding standard.

2. Image Compression Techniques

On the basis of our requirements image compression techniques are following two major categories.

1. Lossless image compression
2. Lossy image compression

2.1 Lossless Compression Techniques

Lossless compression compresses the image by encoding all the information from the original file, so when the image is decompressed, it will be exactly identical to the original image. Examples of lossless image compression are PNG and GIF. When to use a certain image compression format really depends on what is being compressed.

a) Run Length Encoding

Run-length encoding (RLE) is a very simple form of image compression in which runs of data are stored as a single data value and count, rather than as the original run. It is used for sequential data and it is helpful for repetitive data. In this technique replaces sequences of identical symbol (pixel), called runs. The Run length code for a grayscale image is represented by 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 Vi as shown in the figure. This is most useful on data that contains many such runs for example, simple graphic images such as icons, line drawings, and animations. It is not useful with files that don't have many runs as it could greatly increase the file size. Run-length encoding performs lossless image compression. Run-length encoding is used in fax machines.

b) Entropy Encoding

In information theory an entropy encoding is a lossless data compression scheme that is independent of the specific characteristics of the medium. One of the main types of entropy coding creates and assigns a unique prefix-free code for each unique symbol that occurs in the input. These entropy encoders then compress the image by replacing each fixed-length input symbol with the corresponding variable-length prefix free output codeword.

c) Huffman Encoding

In computer science and information theory, Huffman coding is an entropy encoding algorithm used for lossless data compression. It was developed by Huffman. Huffman coding today is often used as a "back-end" to some other compression methods. The term refers to the use of a variable-length code table for encoding a source symbol where the variable-length code table has been derived in a particular way based on the estimated probability of occurrence for each possible value of the source symbol. The pixels in the image are treated as symbols. The symbols which 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 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.

d) Arithmetic Coding

Arithmetic coding is a form of entropy encoding used in lossless data compression. Normally, a string of characters such as the words "hello there" is represented using a fixed number of bits per character, as in the ASCII code. When a string is converted to arithmetic encoding, frequently used characters will be stored with little bits and not-so-frequently occurring characters will be stored with more bits, resulting in fewer bits used in total. Arithmetic coding differs from other forms of entropy encoding such as Huffman coding in that rather than separating the input into component symbols and replacing each with a code, arithmetic coding encodes the entire message into a single number.

2.2 Lossy Compression Techniques

Lossy compression as the name implies leads to loss of some information. The compressed image is similar to the original uncompressed image but not just like the previous as in the process of compression some information concerning the image has been lost. They are typically suited to images.
The most common example of lossy compression is JPEG. An algorithm that restores the presentation to be the same as the original image is known as lossy techniques. Reconstruction of the image is an approximation of the original image, therefore the need of measuring of the quality of the image for lossy compression technique. Lossy compression technique provides a higher compression ratio than lossless compression. Major performance considerations of a lossy compression scheme include:

- Compression ratio
- Signal to noise ratio
- Speed of encoding & decoding

Lossy image compression techniques include following schemes:

a) Scalar Quantization

The most common type of quantization is known as scalar quantization. Scalar quantization, typically denoted as Y=Q (x), is the process of using a quantization function Q to map a scalar (one-dimensional) input value x to a scalar output value Y. Scalar quantization can be as simple and intuitive as rounding high-precision numbers to the nearest integer, or to the nearest multiple of some other unit of precision.

b) Vector Quantization

Vector quantization (VQ) is a classical quantization technique from signal processing which allows the modeling of probability density functions by the distribution of prototype vectors. It was originally used for image compression. It works by dividing a large set of points (vectors) into groups having approximately the same number of points closest to them. The density matching property of vector quantization is powerful, especially for identifying the density of large and high-dimensioned data. Since data points are represented by the index of their closest centroid, commonly occurring data have low error, and rare data high error. This is why VQ is suitable for lossy data compression. It can also be used for lossy data correction and density estimation.

3. TYPE OF IMAGES

There are many types of images based on application. All the types of images are discussed below:

1. **JPEG (Joint Photographic Expert Group)**
2. **TIFF (Tagged Image File Format)**
3. **GIF (Graphic Interchange Format)**
4. **PNG (Portable Network Graphics)**
5. **PDF (Portable Document Format)**

3.1 JPEG

For storing and displaying color or grayscale photographic material, there is no better format than JPEG. While a comparable density in JPEG format is much larger than a comparable TIFF, adequate viewing can be achieved at a lower density. JPEG files will begin displaying segments of a recognizable image as it streams, without requiring the entire file to be transmitted. JPEG also supports watermarks and digital signatures.

3.2 TIFF

TIFF format requires compatible viewers to be installed at every workstation for display and output requirements. TIFF can contain a mix of raster or vector graphics. TIFF can also be compressed in different ways, using the lossy method that jpg use or lossless methods. Though typically, TIFF use lossless compression for raster images.

3.3 GIF

GIF format has evolved into a commonly used format for bitmap graphics on the Internet. Browsers often display GIFs using their native code; however, they are not suited for business document imaging. The special features, such as animation, are not of value in a business setting. In addition, the poor compression of the GIF format makes it less appealing to businesses in comparison to other formats.

3.4 PNG

PNG files are basically a replacement for gif files. PNG use a compression method similar to gif's, but are not limited to a 256 color palette. PNG images can contain full 16.7 million colors available.PNG images also support transparency.

3.5 PDF

A PDF file is a "read only" document that cannot be altered without leaving an electronic footprint, and meets all legal requirements to be admissible in a court of law. Furthermore, the PDF file format is practical and economical by allowing the documents to be stored on a company's server. This eliminates the need for additional hardware (except for additional hard drive space) and allows for exceptional integration into any network.

The PDF format was originally developed by Adobe for the U.S. Federal Government to store its legacy files. Currently, the U.S. Federal Government is still the largest user of PDF technology. Most individuals have encountered the PDF format when downloading electronic tax forms from the IRS.

Table: Image File Format

Name	Extension	Bit Depth	Compression
JPEG	.jpeg, .jpg	8-bit greyscale	Lossless
TIFF	.tif, .tiff	4- or 8- bit greyscale	Uncompressed lossless
GIF	.gif	1-8 bit greyscale	Lossless
PNG	.png	1-48 bit	Lossless
PDF	.pdf	4-bit greyscale	Uncompressed Lossless

4. Conclusion

Images are important documents today to work with them in some applications there is need to be compressed. Compression is more or less it depends on our aim of the application. Image compression plays a very important role in the transmission and storage of image data as a result of and storage limitations. The main aim of image compression is to represent an image in the fewest number of bits without losing the essential information content within an original image. This paper presents various techniques of image compression. After study of all techniques it is found that lossless image compression techniques are most effective over the lossy compression techniques. Lossy provides a higher compression ratio than lossless.

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