INTERNATIONAL JOURNAL OF DATA SCIENCE RESEARCH

IJDSR, Volume 2, Issue 1 June 2019, Al-Madinah International University

Malaysia

Image Compression Technique: Review

Mohamed Yassin Abdelwahab [1]

[a] *Faculty of Computer and Information Technology, Al-Madinah International University, Malaysia, mohcsc_shorouk@hotmail.com*

Abstract

Image compression is the application of data compression on digital images. The objective is to reduce redundancy of the image data in order to be able to store or transmit data in an efficient form. An image, in its original form, contains huge amount of data which demands not only large amount of memory requirements for its storage but also causes inconvenient transmission over limited bandwidth channel. So, one of the important factors for image storage or transmission over any communication media is image compression. Compression makes it possible for creating file sizes of manageable, storable and transmittable dimensions.

Image compression reduces the data from the image in either lossless or lossy way. In lossless image compression retrieves the original image data completely, it provides very low compression. Here different lossless image compression techniques through which high compression ratio be achieved are discussed.

Keywords: *Image, Image compression technique, Lossless and lossy image compression*

I. INTRODUCTION

Space or storage compression is the reduction of the storage requirements of any entity. In an Internetwork, we should compromise between compression and acceptable throughput.

Image compression is an application of data compression that encodes the original image with few bits. The objective of image compression is to reduce the redundancy of the image and to store or transmit data in an efficient form.

The main purpose of image compression is to reduce the redundancy and irrelevancy present in the image, so that it can be stored and transferred efficiently. The compressed image is represented by less number of bits compared to original. Hence, the required storage size will be reduced, consequently maximum images can be stored and it can transferred in faster way to save the time, transmission bandwidth.

There are some practical applications of image compression in many areas of digital field. To mention some of these, image compression is important for web designers who want to create faster loading web pages which in turn will make website more accessible to others.

Image compression is also important for people who attach photos to emails which will send the email more quickly, save bandwidth costs. This makes people very upset because the email takes a long time to download and it uses up their precious bandwidth. This image compression will also save us a lot of unnecessary bandwidth by providing high-quality image with fraction of file size.

In digital camera users and people who save lots of photos on their hard drive, Image Compression is more important. By compressing image we've taken or download, we can store more images on my disk thus saving my money from purchasing bigger hard disk. So, we can reduce image file size by compressing them into JPG files with lower quality. In contrast, Image Compressor with its Digital Eye Functionality prevent us from putting too much compression on image. Digital Eye Functionality works much like human eyes. It automatically detects the quality and optimize the compression level until both quality and file size are optimum the goal of all image-coding algorithms is to provide an efficient way to compress and communicate image information. High-bandwidth networks do provide seamless delivery of image content; however, low bandwidth networks often have large latencies before the end user can even view the image or interact with it. Although the state-of-the-art techniques that use DCTs and wavelets do provide good compression, transmission of digital images is still challenging with the growing number of images, their sizes, real-time interaction with compressed images, and the variety of bandwidths on which transmission needs to be supported [1].

In browsing digital libraries, the images need to be delivered in some form; normally JPEG-encoded images are displayed in HTML form. The delivery of the images in lower bandwidth connections, the sequential image delivery hinders the good experience because the images is being sent block by block. A better experience could be obtained by delivering all the data quickly in a coarse form first, where the user can immediately get a full view of the images [2].

INTERNATIONAL JOURNAL OF DATA SCIENCE RESEARCH

IJDSR, Volume 2, Issue 1 June 2019, Al-Madinah International University

Malaysia

II. CLASSES OF IMAGE COMPRESSION TECHNIQUES

A. Lossy Compression

In the lossy compression techniques, the scheme works such that while storing the information in the chosen compressed format, it does loss certain pieces of it; and, even the decompression scheme cannot retrieve the information-content of the compressed entity to its original form[3, 4].

The lossy image compression, permits reconstruction only of an approximation of the original data, though this usually allows for improved compression rates and therefore smaller sized files. Lossy compression is the class of data encoding methods that uses inexact approximations (or partial data discarding) for representing the content that has been encoded. Such compression techniques are used to reduce the amount of data that would otherwise be needed to store, handle, and/or transmit the represented content. Using well-designed lossy compression technology, a substantial amount of data reduction is often possible before the result is sufficiently degraded to be noticed by the user. Even when the degree of degradation becomes noticeable, further data reduction may often be desirable for some applications[5, 6].

1. Transform Image Coding

Transform coding is a type of data compression for "natural" data like audio signals or photographic images. The transformation is typically lossy, resulting in a lower quality copy of the original input.

In transform coding, knowledge of the application is used to choose information to discard, thereby lowering its bandwidth. The remaining information can then be compressed via a variety of methods. When the output is decoded, the result may not be identical to the original input, but is expected to be close enough for the purpose of the application [7].

Image compression operates by performing entropy coding after the transform computation and quantization of the transform coefficients.

The encoder proceeds in three steps: transform computation, quantization of the transform coefficients, and entropy coding of the quantized values. The decoder only has two steps: the entropy decoding step that regenerates the quantized transform coefficients and the inverse transform step to reconstruct the image. The quantization step present in the encoder is the main cause of the loss[].

2. Wavelet Based Coding (JPEG 2000)

JPEG 2000 is an image compression standard and coding system. It was created by the Joint Photographic Experts Group committee in 2000 with the intention of superseding their original discrete cosine transform-based JPEG standard (created in 1992) with a newly designed, wavelet-based method. The JPEG 2000 compression pipeline makes use of the Discrete Wavelet transform (DWT) to compress images. While there is a modest increase in compression performance of JPEG 2000 compared to JPEG, the main advantage offered by JPEG 2000 is the significant flexibility of the code stream. The code stream obtained after compression of an image with JPEG 2000 is scalable in nature, meaning that it can be decoded in a number of ways; for instance, by truncating the code stream at any point, one may obtain a representation of the image at a lower resolution, or signal-to-noise ratio.

3. Fractal Image Coding

Fractal compression is a lossy compression method for digital images, based on fractals. The method is best suited for textures and natural images, relying on the fact that parts of an image often resemble other parts of the same image. Fractal algorithms convert these parts into mathematical data called "fractal codes" which are used to recreate the encoded image. The DCT and DWT transform-based techniques described previously work by transforming the image to the frequency domain and minimizing the distortion (via appropriate quantization) given a bit rate. Fractal image compression techniques work by attempting to look for possible self-similarities within the image. If aspects of the image can be self-predicted the entire image can be generated using a few image seed sections with appropriate transformations to create other areas of the image.

B. Lossless Compression

In the lossless compression techniques, the compression scheme ensures that while storing the information in the chosen compressed format, it does not loss any piece of it out and the decompression scheme guarantees that uncompressed form and original form are exactly the same.

With lossless compression, data is compressed without any loss of data. It assumes you want to get everything back that you put in. Critical financial data files are examples where lossless compression is required. Lossless data compression is a class of data compression algorithms that allows the original data to be perfectly reconstructed from the compressed data.

The first compression schemes were designed to compress digital images for storage purposes, and were based on lossless coding techniques. Compared with lossy techniques, purely lossless compression can only achieve a modest amount of compression, so their use is somewhat limited in practice today. However, certain applications do need to store images in lossless form for example, the film industry renders images and the original image sequences are always stored in lossless form to preserve image quality.

Lossless compression is used in cases where it is important that the original and the decompressed data be identical, or where deviations from the original data could be deleterious. Typical examples are executable programs, text documents, and source code. Some image file formats, like PNG or GIF, use only lossless compression, while others like TIFF and MNG may use either lossless or lossy methods.

1. Run-length encoding (RLE)

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, simple graphic images such as icons, line drawings, and animations.

2. Lempel–Ziv–Welch (LZW)

Lempel–Ziv–Welch (LZW) is a universal lossless data compression algorithm created by Abraham Lempel, Jacob Ziv, and Terry Welch.

LZW compression became the first widely used universal data compression method on computers. A large English text file can typically be compressed via LZW to about half its original size.

LZW was used in the public-domain program compress, which became a more or less standard utility in UNIX systems circa 1986. It has since disappeared from many distributions, both because it infringed the LZW patent and because gzip produced better compression ratios using the LZ77-based DEFLATE algorithm, but as of 2008 at least FreeBSD includes both compress and uncompressed as a part of the distribution. Several other popular compression utilities also used LZW, or closely related methods.

III. PRIMARY CLASSES OF DATA ENCODING TECHNIQUES

There are many different Data Encoding Techniques belonging to different classes. Selected techniques will be described in the following sections.

2.1. Entropy Encoding

This is a lossless encoding technique that does not make any distinction between data-bits on the basis of its characteristics.

2.1.1. Statistical / Arithmetic encoding technique

2.1.2. Suppressive Repetitive Sequences-based encoding technique

2.2. Source Encoding

2.2.1. Source symbols encoded in binary,

2.2.2. The average code-length must be reduced,

2.2.3. Remove redundancy ⇒ reduces bit-rate.

2.3. Statistical Encoding / Arithmetic Compression Technique

First: the given textual data or file is analyzed.

Second: a Concurrence Table which is a table of repetitive usage is generated for select patterns (sequence of characters).

Third: using a specifically designed compressed representation format every such occurrence is encoded.

The encoded output then has lesser number of bits. Two such techniques are:

2.3.1. Morse Code Encoding Technique

2.3.2. Huffman Encoding Technique

2.4. Repetitive Sequence Suppression based Encoding Technique

a) Determine the presence and locations of long repetitive bit-sequences (in succession) in the data file and then,

b) Replace each of such sequences by a shorter symbol or special bit-pattern.

2.5. Differential Source Encoding Techniques

These techniques are employed when data blocks (each block represents a Frame) have minimum degree of changes (Human eye or ear cannot recognize) with respect to their immediate predecessors and successors. A continuous audio signal or a motion video is a good example

Some of such encoding techniques include:

2.5.1. Pulse Code Modulation (PCM)

2.5.2. Delta PCM

2.5.3. Adaptive Delta PCM

2.5.4. Differential PCM

2.6. The Transform based Source Encoding Techniques

Original input image and video, we encode a transform of the input image and video. Since the redundancy in the transform domain is greatly reduced, the coding efficiency is much higher compared with directly encoding the original image and video. This technique makes use of any suitable mathematical transform for attaining the reduced storage or bandwidth requirement for a give data. Higher coefficients are encoded precisely and lower coefficients are often encoded with less precision in such Transform Encoding cases.

Examples of such transforms include:

2.6.1. Fourier Transform

2.6.2. Discrete Cosine Transform

2.7. Huffman Encoding Techniques

Pure Huffman Encoding is a systematic procedure for encoding a source alphabet with each source symbol having an occurrence probability. It involves use of a variable length code for each of the elements within the information. This technique encodes the most probable elements with lesser number of bits whereas encoding of the least probable elements is done using greater number of bits.

2.8. Adaptive Huffman Encoding

INTERNATIONAL JOURNAL OF DATA SCIENCE RESEARCH

IJDSR, Volume 2, Issue 1 June 2019, Al-Madinah International University

Malaysia

This variation was first suggested by Faller and Gallager and subsequently modified by Knuth. Therefore it is also known as FGK Encoding Technique. Unlike its pure version, the adaptive version provides optimal encoding by adapting the encoding process as per analytical statistics of a piece of data. The encoder thus learns to react to the locality-specific needs.

2.9. The Lampel-Ziv Encoding Techniques

These techniques use the Adaptive Dictionary-based Data Compression Schemes.

2.9.1. Pure (LZ)

2.9.2. Welsh variation (LZW)

- Fixed Length
- Variable Length

Both Huffman and arithmetic coding techniques are based on a statistical model, and the occurrence probabilities play a particular important role. In dictionary-based data compression techniques a symbol or a string of symbols generated from a source alphabet is represented by an index to a dictionary constructed from the source alphabet. A dictionary is a list of symbols and strings of symbols. In the adaptive approach a completely defined dictionary does not exist prior to the encoding process and the dictionary is not fixed. At the beginning of coding, only an initial dictionary exists. It adapts itself to the input during the coding process.

2.10. The Lampel-Ziv Welsh (LZW-78) Encoding Technique

This technique was originally suggested in 1978 as an improvement over the LZ-77. Its basic idea is to locate the type and frequency of repetition, build a dictionary of the Most Frequently Used characters or bytes and use a special identifier called 'Flag' for distinguishing compressed data from uncompressed data.

The LZW technique:

a. **First:** forms an initial dictionary: this dictionary consists of all the individual source symbols contained in the source alphabet.
b. **Second:** the encoder examines the input symbol. Since the input symbol matches to an entry in the dictionary, its succeeding symbol is cascaded to form a string. The cascaded string does not find a match in the initial dictionary. Hence, the index of the matched symbol is encoded and the enlarged string (the matched symbol followed by the cascaded symbol) is listed as a new entry in the dictionary. The encoding process continues in this manner.

2.11. The V.42 bis / British Telecom Lampel-Ziv (BTLZ) Compression:

Compression scheme had the following characteristics that made it suitable for use in dial-up Modems:

- It can be easily implemented on 8/16-bit microprocessors.
- It has low resource requirements specifically in terms of Memory.
- It has incorporated its dictionary-size including its code word notation as well as representation scheme.
- It supports dictionary pruning.
- Control codes 0, 1 and 2 are reserved. Due to the provision '1', the initial stings are required to be indicated by the indices 3 through 258 (instead of the default 0-255) and index of the new strings entries in the dictionary begin with 259.
- Allows 256 strings of one character length.

Dictionary Pruning: This refers to the act of removing dictionary entries. The V.42 bis uses the Least Recently Used (LRU) Algorithm for selecting the strings to be removed from the dictionary.

IV. THE GIF COMPRESSION

The term GIF stands for the Graphics Interchange Format. It comes into multiple flavors primarily emanating from two versions: GIF 87a and GIF 89a. This format was popularized by the CompuServe in the eighties and is a commonly used scheme for encoding still images in normal, interlaced and animated forms.

The GIF algorithm is based on a variant of the LZW scheme described earlier. It can be briefly described as below:

Step-1. Initialize the string table;
Step-2. [Start-prefix] = Null;
Step-3. NextChar = next character in character-stream;
Step-4.
Is [Start-prefix] NextChar present in string table?
If yes: [Start-prefix] = [Start-prefix] NextChar; go to Step-3;
If no: add [Start-prefix] NextChar to the string table;
Write the code for [Start-prefix] to the code-stream;
[Start-prefix] = NextChar;
Step-5. Go to Step-3;

The definition of the GIF Format includes a Data Stream comprising of the Header, the Logical Screen Descriptor, a Global Color Table and the GIF Trailer. It cannot support more than 8-bit color description (i.e. 256 colors).

3. THE PNG COMPRESSION

The term PNG stands for the Portable Network Graphics. It was based on a W3C recommendation document for still images. The PNG scheme is a combination of two schemes: Predictive Encoding Scheme and Entropy Encoding Scheme

PNG and GIF share the following features (Murray and VanRyper 1996):

- Format organized as a data stream
- Lossless image data compression

- Storage of index-mapped images containing up to 256 colors
- Progressive display of interlaced image data
- Transparent key color supported
- Ability to store public and private user-defined data
- Independent from hardware and operating system.

The following GIF features have been improved upon in PNG (Murray and VanRyper 1996):

- Legally unencumbered method of data compression
- Faster progressive display interlacing scheme
- Greater extensibility for storing user-defined data

The following PNG features are not found in GIF (Murray and VanRyper 1996):

- Storage of true color images of up to 48 bits per pixel
- Storage of gray-scale images of up to 16 bits per pixel
- Full alpha channel
- Gamma indicator
- CRC method of data stream corruption detection
- Standard toolkit for implementing PNG readers and writers
- Standard set of benchmark images for testing PNG readers

4. THE JPEG COMPRESSION

The term JPEG stands for the Joint Photographic Experts Group. The original JPEG was a DCT-based scheme and had following modes [4]

- Lossless Mode
- Lossy Mode
- Baseline Mode
- Progressive Mode
- Hierarchical Mode

JPEG uses a set of algorithms some of which are interchangeable in terms of functionalities of compression category and quality. The currently prevalent JPEG standard [ISO-JPEG-1] has forty-four modes, many of which are application specific and are not used commonly. There are several variants of JPEG based on these modes and a few small enhancements [4]. These include:

- L-JPEG
- LS-JPEG
- Motion-JPEG

The JPEG compression scheme is divided into the following stages (Murray and VanRyper 1996):

- Transform the image into an optimal color space.
- Down sample chrominance components by averaging groups of pixels together.
- Apply a Discrete Cosine Transform (DCT) to blocks of pixels, thus removing redundant image data.
- Quantize each block of DCT coefficients using weighting functions optimized for the human eye.
- Encode the resulting coefficients (image data) using a Huffman variable word-length algorithm to remove redundancies in the coefficients.

5. THE MPEG COMPRESSION

The term MPEG stands for "Motion Picture Experts Group". This is a layered encoding scheme that comes into a variety of flavors and versions including the following:

- MPEG-1
- MPEG-2
- MPEG-4
- MPEG-7
- MPEG-21

Standards like MPEG-1, MPEG-2, MPEG-4, MPEG-7 and MPEG-21 belong to the Continuous Media category of media objects. Put together, these are often referred to as MPEG-x standards. The popular audio format MP3 actually stands for MPEG-1 (Audio) Layer-3. Similarly, MPEG-4 VTC stands for MPEG-4 Visual Texture Coding.

MPEG-1 (Steinmetz, R. and Nahrstedt, K. 2011)

- Initial audio/video compression standard
- Used by VCD's
- MP3 = MPEG-1 audio layer 3
- Target of 1.5 Mb/s bitrate at 352x240 resolution
- Only supports progressive pictures

MPEG-2 (Steinmetz, R. and Nahrstedt, K. 2011)

- Current de facto standard, widely used in DVD and Digital TV
- Ubiquity in hardware implies that it will be here for a long time
- Transition to HDTV has taken over 10 years and is not finished yet
- Different profiles and levels allow for quality control

MPEG-3 (Steinmetz, R. and Nahrstedt, K. 2011)

- Originally developed for HDTV, but abandoned when MPEG-2 was determined to be sufficient
- MPEG-4 (Steinmetz, R. and Nahrstedt, K. 2011)
- Includes support for AV "objects", 3D content, low bitrate encoding, and DRM
- In practice, provides equal quality to MPEG-2 at a lower bitrate, but often fails to deliver outright better quality

MPEG-4 Part 10 is H.264, which is used in HD-DVD and Blu-Ray

MPEG-7 [2]

- The descriptors in MPEG-7 allow creating various kinds of descriptions, which can be formally grouped into three categories: archival descriptors, perceptual descriptors, and organization or content access descriptors
- MPEG-7 is a standardized XML-based description scheme with a description interface that provides a systematic way for users to describe media information using standardized descriptors. This allows for a standardized way to process audiovisual description

information in applications that need to access, query, filter, and browse the content.

MPEG-21 [2]
MPEG-21 provides an open framework that can enable multimedia information exchange and consumption among various players in the content creation, delivery, and consumption chain.
MPEG-21 achieves this universal exchange using a few key concepts:

- Describing all content in a standardized manner in way that is scalable via standardized descriptors. Such a description, termed a Digital Item, is the fundamental unit for exchange.
- Allowing a Digital Item to be adapted for interpretation on a terminal. This entails knowledge of the Digital Item's requirements and the capabilities of the terminal and/or network.
- Consuming or processing the Digital Item so users can interact with the terminal to consume the Digital Item.

In data compression also presented special filter band-pass filter [4] before transformation and entropy coding in order to preprocessing data as first stage of image compression model [9].

Data compression technique is gain many methods have used several technique such as discrete cosine transform, discrete wavelet transform included neural network and deep learning methods to enhance compression ratio, the main popular neural network in area of data compression is unsupervised learning model such as self-organization feature map SOFM [10] the author presented SOFM and principle of vector quantization and entropy coding [11].

Bit rate optimization and energy rate reduction or data compression in signal processing utilizes encoding techniques by bits representation compare to original form in several data transmission networks such as in such wireless, mobile, [13, 14] and powerline communications. The techniques of compression are used for the benefit of resources optimization and efficiency required to store and transfer bits [15].

V. CONCLUSION

This paper represents the concept of image compression and various technologies used in the image compression. All the image compression techniques are useful in their related areas and every day new compression technique is developing which gives better compression ratio. This review paper gives clear idea about basic compression techniques and image types.

Specific needs of the MMI-specific applications range from MM-specific Data Representation, Manipulation, Transmission, Storage, and Management to MM-specific Retrieval.

Many solutions to this set of requirements have been suggested. Some of these solutions are completely Software Codec based whereas some other solutions need specialized Hardware as well as the Software Codec. Pure Software Codec often provides smaller video-window sizes.

The MPEG-1 and MPEG-2 standards have enabled the wide spread use of MP3, digital audio broadcasting (DAB), digital television and several experimental Video-on-Demand systems among others. MPEG-4 is a multimedia representation standard that models audiovisual data as a composition objects. MPEG-4 also supports the mobile multimedia. The MPEG-7 standard, called as the "Multimedia Content Description Interface", provides standardized tools for description of multimedia content.

Instead of delivering the compressed data at a full resolution in a sequential manner, it will be more effective to transmit a part of the bit stream that approximates the entire image first. The quality of this image can then progressively improve as data arrives at the end terminal. The central issue to all these problems is that the end terminal needs to have all the data pertaining to the compressed bit stream prior to effectively decoding and displaying the image. Rather than delivering the data stream in an absolute fashion, reorganizing the bit stream and delivering it in a progressive manner can be more effective.

REFERENCES

[1]. Banerjee, Rahul. Internetworking Technologies: An Engineering Perspective. Prentice-Hall of India Pvt. Ltd, 2004.
[2]. Havaldar, Parag, and Gérard Medioni. Multimedia Systems: Algorithms, Standards, and Industry Practices. USA: Course Technology, Cengage Learning, 2010.
[3]. Melnick, Jack, and Eric Paapanen. Oracle Database SecureFiles and Large Objects Developer's Guide. Vers. 11g Release 1 (11.1). 2008. http://docs.oracle.com/cd/B28359_01/appdev.111/b28393/adlob_intro.htm.
[4]. Hilles, S., & Maidanuk, V. P. (2014). Self-organization feature map based on VQ components to solve image coding problem. ARPN Journal of Engineering and Applied Sciences. Vol. 9,№ 9: 1469-1475.
[5]. Murray, J.D., and W. VanRyper. Encyclopedia of Graphics File Formats. Vol. 2nd Edition. O'Reilly Media, 1996.
[6]. Shi, Yun Q., and Huifang Sun. Image and video compression for multimedia engineering: fundamentals, algorithms, and standards. CRC Press, 2000.
[7]. Steinmetz, R. and Nahrstedt, K. Multimedia Applications. Springer, X. media. Publishing Series, 2011.
[8]. P. Havaldar and G. Medioni, "Multimedia Systems Algorithm, Standards, and Industry Practices" Course
[9]. L. P. Rieber, "Computer graphics and learning With Java, OpenGL, and Jogl, The University of

GeorgiaAthens,http://www.imagecompressor.com/index.cfm?fuseaction=product.features_compress.

[10]. Hilles, S. M. (2018, July). Sofm And Vector Quantization For Image Compression By Component. In 2018 International Conference on Smart Computing and Electronic Enterprise (ICSCEE) (pp. 1-6). IEEE.

[11]. Hilles, S. M. (2018, July). Spatial Frequency Filtering Using Sofm For Image Compression. In 2018 International Conference on Smart Computing and Electronic Enterprise (ICSCEE) (pp. 1-7). IEEE.

[12]. Ibrahim, R., Hilles, S. M., Adam, S. M., & El-Ebiary, Y. (2016). Methodological Process for Evaluation of E-government Services base on the Federal Republic of Nigerian Citizen’s E-government Services usage. Indian Journal of Science and Technology, 9(28).

[13]. Altrad, A. M. M., Osman, W. R. S., & Nisar, K. (2012). Modelling of Remote Area Broadband Technology over Low Voltage Power Line Channel. International Journal of Computer Networks & Communications, 4(5), 187.

[14]. Osman, W. R. S., Nisar, K., & Altrad, A. M. (2014, August). Evaluation of broadband PLC technology over Malaysia's indoor power line network. In 2014 2nd International Conference on Electronic Design (ICED) (pp. 275-280). IEEE.

[15]. Altrad, A. M., Amphwan, A., & Hilles, S. M. (2018, July). Adaptive Shuffled Frog Leaping Algorithm For Optimal Power Rate Allocation: Power Line. In 2018 International Conference on Smart Computing and Electronic Enterprise (ICSCEE) (pp. 1-5). IEEE.