A Survey on Different Types of Image Formats and Compression Techniques

Vrinda Shivashetty[1], G.G Rajput[2]

[1, 2] Department of Computer Science, Gulbarga University, Gulbarga, India

Abstract: ***This paper gives review of different types of Images and the different techniques for Image compression. Image compression is a method through, which we can reduce storage space of images, which will be helpful to increase storage and transmission process's performance. Image compression techniques are classified into two categories lossy technique and lossless technique. Lossy compression technique provides higher compression ratio than lossless compression, the decompressed image is not exactly identical to the original image, but close to it. In Lossless compression techniques, the original image can be perfectly recovered from the compressed image. The analysis of various compression techniques provides knowledge in identifying the advantageous features and helps in choosing correct method for compression.***

Keywords: Image compression, Mean Square Error, Peak Signal to Noise Ratio, Compression techniques, Lossy compression technique, Lossless compression techniques.

1. Introduction

Images contain large amounts of information that requires much storage space, large transmission bandwidths and long transmission times. Therefore it is advantageous to compress the image by storing only the essential information needed to reconstruct the image. An image is essentially a 2-D signal processed by the human visual system. The signals representing images are usually in analog form. However, for image processing, storage and transmission, they are converted from analog to digital form. A digital image is basically a 2-D array of pixels.

1.1 Image Compression

Image compression is minimizing the size of an image without degrading the quality and information of image. Image compression is an application of data compaction that can reduce the quantity of data. Image compression addresses the problem of reducing the amount of data required to represent a digital image. such that they can be transmitted quicker and then decompressed by the receiver. Image compressions have two main components: redundancy reduction and irrelevant data reduction. Redundancy reduction is achieved by removing extra bits or repeated bits. While in irrelevant data reduction the smallest or less important information is omitted, which will not be received by receiver. Compression is achieved by the removal of one or more of the following three types of redundancies:

1. Coding Redundancy
2. Inter-pixel Redundancy
3. Perceptual Redundancy

Coding redundancy is present when less number of code words required instead of larger symbol. Inter pixel redundancy results from correlated pixels of an image. Perceptual redundancy is due to data that is ignored by the human visual system. Image compression is applied to reduce the number of bits which represent the image.

1.2 Performance Parameters

Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR) are two performance parameters used to measure the performance of the various image compression techniques. The MSE is the cumulative squared error between the compressed and the original image, whereas PSNR is the measurement of the peak error between the compressed image and original image. If we find a compression scheme having a lower MSE and a high PSNR, we can recognize that it is a better one. To compute the PSNR first of all MSE (mean square error) is computed. Mean Square Error (MSE) is the cumulative difference between the compressed image and original image. Small amount of MSE reduce the error and improves image quality.

$$MSE = \frac{\sum_{M,N} [I_1(m,n) - I_2(m,n)]^2}{M * N} \quad (1)$$

In equation (1), M and N are the number of rows and columns in the input images. The PSNR is computed from following equation

$$PSNR = 10\log_{10}\left(\frac{R^2}{MSE}\right) \quad (2)$$

1.3 Image Compression and Decompression Process

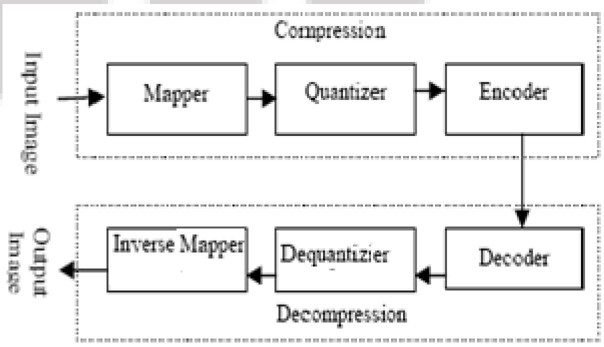

Figure1: Image compression and decompression system

As shown in Figure1, the image is taken from the image dataset. The mapper converts the input image into inter pixel coefficients. Transformation for the mapper may be DCT, wavelet or Curvelet transform. Each has its own advantages and disadvantages. Second stage is the quantizer which simply reduces the number of bits needed to store the transformed coefficients. It is many to one mapping in which larger values are quantized into smaller value. It is a lossy process and it is the main source of compression in an encoder. Quantization reduced the number of bits so it results some kind of information loss. Quantizer can be scalar or vector quantization.

In scalar Quantizer quantization is performed on each coefficient while in vector quantization it can be performed on groups. An entropy encoder compressed the quantized values and improves the compression. The reverse Process Decoder, De quantizer and inverse mapper is obtained to reconstruct the image and it is called decompression.

1.3 Organization of Paper

In this paper, we present in section II review on various types of image formats is discussed and Image compression techniques in section III. In section IV general guidelines are given to compress the image.

2. Types of Image Formats

2.1 Tagged Image File Format (.tif, .tiff)

The TIFF is a flexible format which can be used for lossless or lossy Compression. Generally TIFF is used as a lossless image storage format in which image compression is not used. TIFF files require large size so TIFF files are not used for web transmission.

2.2 Portable Network Graphics (.png)

The PNG file format supports 8 bit, 24 bit, 48 bit true color with an optional alpha channel. Typically, an image in a PNG file can be 10% to 30% more compressed than in a GIF format. PNG format files are smaller in size and have more colors compare to other types of image formats.

2.3 Graphics Interchange Format (.gif)

Graphics Interchange Format (GIF) is useful for images that have less than 256 colors, grayscale. GIF is limited to an 8 bit or 256 colors. So that it can be used to store simple graphics, logos and cartoon style images. It uses loss less compression.

2.4 RAW

RAW file format includes images directly taken from Digital cameras. These formats normally use loss less or lossy compression method and produce smaller size Images like TIFF. The Disadvantage of RAW Image is that they are not standardized image and it will be different for different manufactures. So these images require manufacture's software to view the images.

2.5 Joint Photographic Expert Group (JPEG)-(.jpg)

Joint Photographic Expert Group (JPEG) is a lossy compression technique to store 24 bit photographic images. It is widely accepted in multimedia and imaging industries. JPEG is 24 bit color format so it have millions of colors and more superior compare to others. It is used for VGA(video graphics Array) display.JPEG have lossy compression and it support 8 bit gray scale image and 24 bit color images.

2.6 JPEG2000

JPEG 2000 is a compression standard for lossless and lossy storage. JPEG2000 improves the JPEG format. It is nearly same as JPEG.

2.7 WEBP

WEBP is a new image format that use lossy image compression. It was designed by Google to reduce image file size to increase the speed when web page is loading. It is based on VP8s infraframe coding.

2.8 Exchangeable Image File Format(Exif)

The Exif (Exchangeable Image File Format) is used to record and exchange images with image metadata between the digital camera editing and viewing software.

2.9 Bitmap (BMP)

The Bitmap (BMP) file format deal with graphic file related to Microsoft windows OS. Normally these files are uncompressed so they are large. These files are used in basic windows programming. BMP images are binary Files.BMP file does not support true colors.

2.10 NETPBM

NetPbm format contain three family formats: the PPM (portable Pixel Map), the PGM (portable Gray Map) and the PBM (Portable Bit Map).These files are pure ASCII files or raw binary files.

3. 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. Lossy technique
2. Lossless technique

3.1 Lossy Compression Techniques

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. The most popular current lossy image compression methods use a transform-based scheme.

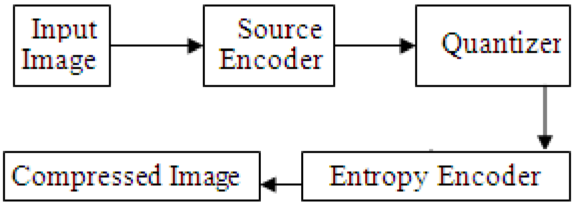

Figure 2: Lossy image compression

Major performance considerations of a lossy compression scheme include:

1. Compression ratio
2. Signal - to – noise ratio
3. Speed of encoding and decoding.

Lossy compression techniques includes following schemes:

1. Transform coding
2. Vector quantization
3. Fractal compression
4. Block truncation coding
5. Subband coding

3.1.1Transform coding

Transform coding algorithm usually start by partitioning the original image into sub images (blocks) of small size (usually 8 x 8). For each block the transform coefficients are calculated, effectively converting the original 8 x 8 array of pixel values into an array of coefficients closer to the top-left corner. Top-left corner usually contain most of the information needed to quantize and encode the image with little perceptual distortion .The resulting coefficients are then quantized and the output of the quantizer is used by a symbol encoding technique(s) to produce the output bit stream representing the encoded image. At the decoder' s side, the reverse process takes place, with the obvious difference that the "dequantization" stage will only generate an approximated version of the original coefficient values; in other words, whatever loss is introduced by the quantizer in the encoder stage is not reversible.

3.1.2 Vector Quantization

The basic idea in Vector Quantization technique is to develop a dictionary of fixed-size vectors, called code vectors. A vector is usually a block of pixel values. A given image is then partitioned into non-overlapping blocks (vectors) called image vectors. Each in the dictionary is determined and its index in the dictionary is used as the encoding of the original image vector. Thus, each image is represented by a sequence of indices that can be further entropy coded.

3.1.3 Fractal Compression

The fractal compression technique relies on the fact that in certain images, parts of the image resemble other parts of the same image. Fractal algorithms convert these parts, or more precisely, geometric shapes into mathematical data called "fractal codes" which are used to recreate the encoded image. Once an image has been converted into fractal code its relationship to a specific resolution has been lost; it becomes resolution independent. The image can be recreated to fill any screen size

3.1.4Block Truncation Coding

In this scheme, the image is divided into non-overlapping blocks of pixels. For each block, threshold and reconstruction values are determined. The threshold is usually the mean of the pixel values in the block. Then a bitmap of the block is derived by replacing all pixels whose values are greater than or equal (less than) to the threshold by a 1 (0). Then for each segment (group of 1s and 0s) in the bitmap, the reconstruction value is determined. This is the average of the values of the corresponding pixels in the original block.

3.1.5Subband Coding

In this scheme, the image is analyzed to produce the components containing frequencies in well-defined bands, the sub bands. Subsequently, quantization and coding is applied to each of the bands. The advantage of this scheme is that the quantization and coding well suited for each of the sub bands can be designed separately.

3.2 Lossless Compression Techniques

In lossless compression techniques, the original image can be perfectly recovered from the compressed image. These are also called noiseless since they do not add noise to the signal. It is also known as entropy coding since it use decomposition techniques to minimize redundancy.

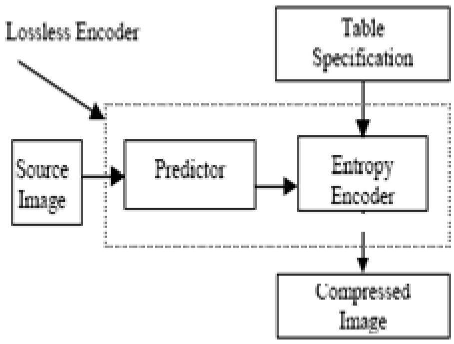

Figure 3: Block Diagram for Lossless compression

Following techniques are included in lossless compression:

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

3.2.1Run Length Encoding

This is a very simple compression method used for sequential data. It is very useful in repetitive data. This technique replaces sequences of identical pixels, called runs by shorter symbols. The run length code for a gray scale image is represented by a sequence {Vi, Ri} where Vi is the intensity of pixel and Ri refers to the number of consecutive pixels with the intensity Vi. If both Vi and Ri are represented by one byte, this span of 12 pixels is coded using eight bytes yielding a compression ration of 1: 5.

3.2.2 Huffman encoding

The Huffman's algorithm is generating minimum redundancy codes compared to other algorithms. The Huffman coding has effectively used in text, image, video compression, and conferencing system such as, JPEG, MPEG-2, MPEG-4, and H.263 etc.. The Huffman coding technique collects unique symbols from the source image and calculates its probability value for each symbol and sorts the symbols based on its probability value. Further, from the lowest probability value symbol to the highest probability value symbol, two symbols combined at a time to form a binary tree. Moreover, allocates zero to the left node and one to the right node starting from the root of the tree. To obtain Huffman code for a particular symbol, all zero and one collected from the root to that particular node in the same order.

3.2.3 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

3.2.4 Arithmetic coding

Arithmetic coding is the most powerful technique for statically lossless encoding that has attracted much attention in the recent years. It provides more flexibility and better efficiency than the celebrated Huffman coding does. The aim Arithmetic coding is to define a method that provides code words with an ideal length. Like for every other entropy coder, it is required to know the probability for the appearance of the individual symbols. Arithmetic coding is the most efficient method to code symbols according to the probability of their occurrence. The average code length is very close to the possible minimum given by information theory. The AC assigns an interval to each symbol whose size reflects the probability for the appearance of this symbol. The code word of a symbol is an arbitrary rational number belonging to the corresponding interval

3.2.5 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.

4. Conclusion

By studying and discussing all the Compression techniques this review paper gives clear idea about image types and basic compression techniques. We find lossy compression techniques provides high compression ratio than lossless compression scheme. Lossy compression is used for more compression ratio and Lossless compression is used when the original image and reconstructed image are to be identical. Based on review of different types of images and its compression algorithms we conclude that the compression algorithm depends on the three factors:

- quality of image
- amount of compression
- Speed of compression.

References

[1] Rafael C. Gonzalez, Richard Eugene; "Digital image processing", Edition 3, 2008, page 466.

[2] Subramanya A. "Image Compression Technique, "potentials IEEE, Vol. 20, issue 1,pp19-23, Feb-March 2001.

[3] Woods, R. C. 2008. Digital Image processing. New Delhi: Pearson Pentice Hall, Third Edition, Low price edition, Pages 1-904.

[4] Hong Zhang, Xiaofei Zhang & Shun Cao, " Analysis & Evaluation of Some Image compression Techniques," High Performance Computing in Asia Pacific Region, 2000 Proceedings, 4th Int. Conference, vol. 2, pp 799-803,14-17 May, 2000

[5] Sonka, M. Hiaual, V. Boyle, R. Image Processing, Analysis and Machine Vision, 2nd edition. Brooks/Cole Publishing Company.

[6] http://en.wikipedia.org/wiki/Image_file_formats

[7] Keshab K. Parhi, Takao Nishitan; "Digital Signal processing for multimedia systems", ISBN 0-8247-1924

[8] "Understanding Image Types " http://www.contentdm.c om/USC/tutorial/image-filetypes.pdf.1997-2005, DiMe Ma,Inc, Unpublished."

[9] http://www.find-images.com

[10] David Jeff Jackson & Sidney Joel Hannah, "Comparative Analysis of image Compression Techniques," System Theory 1993, Proceedings SSST '93, 25th Southeastern Symposium, pp 513-517, 7 –9 March 1993.

[11] John Miano; "Compressed image file formats: JPEG, PNG, GIL, XBM, BMP", Edition- 2, January-2000, page 23. *Majid Rabbani, Paul W.Jones;* "Digital Image Compression Techniques". Edition-4, 1991.page 51.

[12] Ronald G. Driggers; "Encyclopedia of optical engineering", Volume 2, Edition 1, 2003.

[13] Ioannis Pitas; "Digital image processing algorithms and applications.", ISBN 0-471- 37739-2

[14] A.S. Ragab, Abdalla S.A. Mohamed, M.S. Hamid,"Efficiency of Analytical Transforms for Image Compression" 15th National Radio Science Conference, Feb.24-26, 1998, Cairo- Egypt.

[15] Alan Conrad Bovik; "Handbook of image and video processing", Edition 2 1005, page 673

[16] Deke McClelland, Galen Fott; "Photoshop elements3fordummies"Edition 1, 2002, page 126.

[17] Keshab K. Parhi, Takao Nishitan; "Digital Signal processing for multimedia systems", ISBN 0-8247-1924-7, United States of America, page 22.
[18] Majid Rabbani, *Paul W. Jones;* "Digital image compression techniques"; ISBN 0-8194—0648-1, Washington, page 129.
[19] Vasudev Bhaskaran, Konstantinos Konstantinides "Image and video compression standards: algorithms and architectures". Edition 2, 1997,page 61.
[20] Sonal, D. K. 2007"A study of various image compression techniques" COIT, RIMT-IET. Hisar

Author Profile

Vrinda Shiva Shetty received B.E from Gurbarga University and M.Tech degree from VTU in Computer Science and Engineering and presently pursuing Ph.D in Image Compression from the University of Gulbarga University, Gulbarga, and Karnataka. Field of Interest includes Intelligent Image Processing, Evolutionary Computation.

Dr. G. G. Rajput currently working as Associate Professor in the Department of Computer Science at Rani Channamma University Belagavi, Karnataka State, India. The Area of interest includes Image processing, Pattern recognition, Operations Research and Software Engineering.