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A Survey of Image Compression Techniques

Puja Singh[1], Satyaranjan Panda[2]
[1] Assistant Professor, Medi-Caps Institute of Technology and Management, Indore, MP, India
[2] EC Department, Medi-Caps Institute of Technology and Management, Indore, MP, India

Abstract: Introduction of computer technology in various fields has simplified the job of human being but has also resulted in large amount of digital data. The challenge lies in managing this huge amount of data, i.e. storing and retrieving it. The storing resources required for it also increases the cost of the overall system. If one can use some technique to reduce this digital data without losing the original information, then the cost can be cut down to some extent. The process of reducing data size without losing the vital information is known as data compression. There are various data compression techniques one can use. These techniques can be classified into two types i.e. Lossy and Lossless compression. In this paper some of the image compression techniques are discussed in detail.

I. INTRODUCTION

The improvement of digital image quality has caused the size of the image files to increase. This increased size of image files need larger disk size for storage purpose and when it comes to transmitting data over a network they require high bandwidth to transfer them fast. This overall high resource requirement results in increased cost of the system. One of the methods which can aid to reduce the cost is using data compression specifically image compression techniques for storage and transmission purpose. Image compression algorithms can be divided into two types [1][2][3] i.e. lossy in which loss of data takes place during the process of decompression and lossless where the decompressed data is exactly same as the original data. In this paper various types of image compression techniques are discussed briefly.

II. TERMINOLOGIES USED IN IMAGE COMPRESSION

Terms which are used in calculation of image compression are listed below [1][2]:

1. *Data compression ratio*

This, also known as compression power, is used to quantify the reduction in data-representation size produced by a data compression algorithm and is defined as the ratio between the uncompressed size and the compressed size:

Compression Ratio = Uncompressed Size/Compressed Size

Sometimes the space saving is given instead, which is defined as the reduction in size relative to the uncompressed size:

Space Saving = [1- compressed Size/Uncompressed Size]

For data of indefinite size, such as streaming audio and video, the compression ratio is defined in terms of uncompressed and compressed data rates instead of data sizes: Instead of space saving, one speaks of data-rate saving, which is defined as the data-rate reduction relative to the uncompressed data rate:

Data Rate Saving = [1- compressed data rate/Uncompressed data rate]

2. *Peak signal to noise ratio*

The term peak signal-to-noise ratio (PSNR) is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Because many signals have a very wide dynamic range, PSNR is usually expressed in terms of the logarithmic decibel scale.

The PSNR is most commonly used as a measure of quality of reconstruction in image compression etc. It is most easily defined via the mean squared error (MSE) which for two $m \times n$ monochrome images I and K where one of the images is considered a noisy approximation of the other is defined as:

$$MSE = \frac{1}{MN}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\left\| I(i,j) - K(i,j) \right\|$$

The PSNR is defined as:

$$PSNR = 10\log_{10}\left(\frac{MAX_I^2}{MSE}\right) = 20\log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \quad (3.5)$$

Here, MAX_I is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255. More generally, when samples are represented using linear PCM with B bits per sample, MAX_I is 2^B-1.

3. *Signal-to-noise ratio*

It is an electrical engineering concept used in other fields too and is defined as the ratio of a signal power to the noise power corrupting the signal.

In engineering, signal-to-noise ratio is a term for the power ratio between a signal (meaningful information) and the background noise:

$$SNR = \frac{P_{Signal}}{P_{Noise}} = \left(\frac{A_{Signal}}{A_{Sinal}}\right)^2$$

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Where *P* is average power and *A* is RMS amplitude. Both signal and noise power (or amplitude) must be measured at the same or equivalent points in a system, and within the same system bandwidth.

4. Mean Squared Error

In statistics, the mean squared error or MSE of an estimator is one of many ways to quantify the amount by which an estimator differs from the true value of the quantity being estimated. As a loss function, MSE is called squared error loss. MSE measures the average of the square of the "error." The error is the amount by which the estimator differs from the quantity to be estimated. The difference occurs because of randomness or because the estimator does not account for information that could produce a more accurate estimate.

In a statistical model where the estimate is unknown, the MSE is a random variable whose value must be estimated. This is usually done by the sample mean

$$MSE'(\theta') = \frac{1}{n}\sum_{j=1}^{n}(\theta_j - \theta)^2$$

with θ_j being realizations of the estimator of size *n*.

III. IMAGE COMPRESSION ALGORITHMS

Image compression algorithms can be divided into two categories, they are:

a) Lossy image compression.
b) Lossless image compression.

a) Lossy Compression Algorithms are those algorithms which are used to compress data and then decompress it, then retrieve data that may well be different from the original one, but is close enough to be used in some way. These algorithms are generally used to compress multimedia data such as audio, video and image, especially for the applications which are used for streaming media and internet telephony. The biggest drawback of using Lossy compression formats is that it suffers from generation loss i.e. repeated compression and decompression of data using these algorithms will progressively distort the original data. Some of the various Lossy Compression Algorithms are:

a. Cartesian Perceptual Compression: Also known as CPC.
b. HAM, hardware compression of color information used in Amiga computers.
c. DjVu.
d. Fractal compression.
e. ICER, used by the Mars Rovers: related to JPEG 2000 in its use of wavelets.
f. JBIG2.
g. S3TC texture compression for 3-D computer graphics hardware
h. PGF, Progressive Graphics File (lossless or lossy compression) Wavelet compression.

b) Lossless Image Compression or Reversible Compression Algorithms: In these algorithms, the retrieved data exactly matches the original [4]. Lossless compression algorithm gives quantitative bounds on the nature of the loss. These techniques give the guarantee that there will be no pixel difference between the original and the compressed image from the given threshold value. Its potential applications can be remote sensing, space imaging and medical and multispectral image archiving. The necessity to preserve the validity and precision of data in the above mentioned applications often imposes strict constraints on the reconstruction error. Therefore lossless compression becomes a feasible solution, as it provides significantly higher compression gains as compared to lossy algorithms, and simultaneously it provides guarantee bounds on the nature of loss caused by compression. Various Lossless Compression Methods are:

a. Entropy coding
b. Run-length encoding – used as default method in PCX and as one of possible techniques in BMP, TGA, TIFF.
c. Adaptive dictionary algorithms such as LZW – used in GIF and TIFF.
d. Deflation – used in PNG, MNG and TIFF

Following steps are involved in any image compression technique:

Step 1: Specifying the size of data available and acceptable distortion parameters for the target image.

Step 2: Based on their importance, image data is divided into various classes.

Step 3: To minimize the distortion, dividing the available bit budget among these classes.

Step 4: Then separately quantize each class using the bit allocation information derived in step 3.

Step 5: Encoding each class separately using an entropy coder and write to the file.

Step 6: Reconstructing the image from the compressed data which is a faster process as compared to compression. Following steps are involved in it:

Step 7: Reading the quantized data from the file, using an entropy decoder (reverse of step 5).

Step 8: De-quantizing the data (reverse of step 4).

Step 9: Rebuilding the image (reverse of step 2).

IV. TYPES OF IMAGE COMPRESSION

The various types of image compression methods are described below

A. Joint Photographic Experts Group (JPEG)

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JPEG was designed for compressing full-color or gray-scale images of natural, real-world scenes [5][6]. It performs well on photographs, artwork, and similar material; but it is not so suitable for lettering, simple cartoons, or line drawings. JPEG can only handle still images, but there is a related standard called MPEG for motion pictures. And it is a “Lossy” compression technique.

The useful property of JPEG is that the degree of lossiness can be varied by adjusting compression parameters. One can make extremely small files if he does not mind poor quality; this can be useful for applications used for indexing image archives. Another important aspect of JPEG is that decoders can trade off decoding speed against image quality by using fast but inaccurate approximations to the required calculations.

B. Graphics Interchange Format (GIF)

The Graphics Interchange Format is an 8-bit-per-pixel bitmap image format, introduced by CompuServe in the year 1987 and due to its wide support and portability it has come into widespread usage over internet [4]. GIF images can be compressed using the Lempel-Ziv-Welch (LZW) lossless data compression technique.

C. Fractal Image Compression and Decompression

Fractal compression is a type of lossy image compression method. Using this, high levels of compression can be achieved. This method is suitable for photographs of natural scenes. The fractal compression technique relies on the resemblance between the parts of same image. This algorithm converts these parts, specifically, geometric shapes into mathematical data called "fractal codes" which are then used to create the encoded image. The main drawback of the fractal scheme is that it is computationally expensive. Hence, it is required that the coding of image textures must be performed at the server-end of a multi-tier system.

D. Wavelet Based Image Compression and Decompression

Wavelet compression involves analyzing an uncompressed image in a recursive fashion, which results in a series of higher resolution images, each adding to the information content of lower resolution images[7][8].The primary steps involved in wavelet compression are

1. Performing a discrete wavelet Transformation (DWT).
2. Quantization of the wavelet-space image sub bands.
3. Then encoding these sub bands.

Wavelet images by and of themselves are not compressed images; rather they are done in quantization and encoding stages. Image decompression is done by carrying out the above steps in reverse. Thus, to restore the original image, the compressed image is first decoded and then de-quantized, and finally an inverse DWT is performed.

As wavelet compression inherently results in a set of multi-resolution images, it is well suited to work with large imagery which needs to be selectively viewed at different resolutions, as only the levels containing the required level of detail need to be decompressed.

Wavelet mathematics has an entire range of methods each offering different properties and advantages. For example, it is possible to compress 3 or more dimensional image using wavelets. Wavelet compression is not widely used because DWT operation requires a lot of computational power. As historical techniques perform the DWT operation in memory or storing intermediate results on hard disk, this limits the size of the image that can be compressed, or the speed at which it can be compressed.

V. CONCLUSION

In this paper various image compression algorithms were discussed along with their area of usage, strength and weaknesses. On one hand lossy compression though may result in better compression ratio but when it comes to data retrieval it does not give original image, whereas in lossless algorithm compression ratio might be at the lower end but it produces original image in case of image retrieval. So it is up to one’s requirement on the basis of which one can select a specific algorithm out of the available options.

REFERENCES

[1] M. Nelson and J. L Gaily, The data compression book, 2nd ed. New York: M&T books, 1996.

[2] R. C. Gonzalez and R. E. Woods, “Digital Image Processing”, Reading, MA: Addison-Welsley, 1992.

[3] Dr. B. Eswara Reddy and K Venkata Narayana “A Lossless Image Compression Using Traditional and Lifting Based Wavelets”, Signal & Image Processing: An International Journal (SIPIJ) Vol.3, No.2, and April 2012.

[4] Anitha S. “2D image compression technique-A survey”, International Journal of scientific & Engineering Research Volume 2, Issue 7, pp 1-7 July-2011.

[5] A. Bradley and F. Stienford,”JPEG2000 and region of interest coding”,in proc. Int. conf.DICTA2002, Melbourne, Australia, Jan2002 .

[6] Ricardo L. de Queiroz “Processing JPEG-Compressed Images and Documents”, IEEE Transactions on Image Processing, Vol. 7, No. 12, Pp1661-1667december 1998.

[7] Gulay Tohumoglu, “Wavelets and their usage on the medical image compression with a new algorithm”, in Proc. IEEE EURASIP workshop on nonlinear signal and image processing, Turkey, pp.229-233, Jun.1999.

[8] Dr.B Eswara Reddy and K Venkata Narayana “A Lossless Image Compression Using Traditional and Lifting Based

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