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Image Compression Techniques in Networking: Review Paper

Shadi M.S. Hilles[1], Abdullatif Abdulsalam[2]

[1] *Faculty of Computer and Information Technology, Al-Madinah International University (MEDIU), Malaysia, shadihilless@gmail.com*

[2]*Faculty of Computer and Information Technology, Al-Madinah International University (MEDIU), Malaysia, albarzan2007@gmail.com*

Abstract

Data compression is the process of reducing redundancy in data representation in order to achieve savings in storage and communication costs. It is a popular approach to reducing data volumes to lower disk utilization and reduce network traffic, hence reduce data transfer times in distributed computing. The research paper is presented and focused on the significant of using data compression in networking as well as its different types of image compression techniques. They are lossless and lossy image compression methods. It explores comparison for some image format such as jpeg, tiff, bmp, png, included algorithms for each formats, each format such as jpeg2000, and the methods are described in details with using figures. It shows the coding types and categories s such as DPCM, entropy coding, Huffman coding, arithmetic coding, LZW.

Keywords: *DCT, DWT, DPCM, LZW, Huffman coding, Entropy coding, Arithmetic coding*.

I. INTRODUCTION

When working with larger images of greater bit depth, the images tend to become too large to transmit over a standard Internet connection. In order to display an image in a reasonable amount of time, techniques must be incorporated to reduce the image's file size. These techniques make use of mathematical formulas to analyze and condense image data, resulting in smaller file sizes. This process is called compression [13].

The term data compression refers to the process of reducing the amount of data required to represent a given quantity of information [9]. Data compression is a popular approach to reducing data volumes and hence lowering disk I/O and network data transfer times [16]. Data compression is the process of eliminating or reducing the redundancy in data representation in order to achieve savings in storage and communication costs. Data to be compressed can be divided into symbolic or diffuse data. Symbolic data is data that can be discerned by the human eye [8].

Image compression comes in two forms: (1) irreversible, or lossy, or information reducing compression; and (2) reversible, of lossless, or error-free, or information preserving compression. Compression methods are in the second class only if the original data can be exactly reconstructed from the compressed representation[2].

In lossless compression schemes, the reconstructed image is exact replica of the original image. In lossy image compression, the reconstructed image contains degradation relative to the original. In lossy compression, higher compression can be achieved when compared to lossless compression scheme [12].

II. SIGNIFICANT OF USING DATA COMPRESION IN NETWORKING

Data networking means data transmission over various types of networks. This process related to some significant factors such as bandwidth, throughputs, storage capacity and network resources capabilities. Performance quality is major factor in data networking. Hence, need to keep the performance in the level of QoS, and required to implement data compression techniques.

Data compression is the process of eliminating or reducing the redundancy in data representation in order to achieve savings in storage and communication costs. Data compression is a popular approach to reducing data volumes and hence lowering disk I/O and network data transfer times, and the sole purpose is to reducing disk or network traffic in distributed computing [16].

III. IMAGE COMPRESSION METHODS

There are two major compression methods; lossless compression and lossy compression methods.

3.1. Lossless Data Compression Method:

Lossless or reversible compression refers to compression techniques in which the reconstructed data exactly matches the original [3]. lossless data compression technique that

balances the performance between compression and decompression for large-scale geospatial rasters [16]. Traditional lossless image coders usually consist of computationally intensive modelling and entropy coding phases, therefore might not be suitable to mobile devices or scenarios with a strict real-time requirement.

Following techniques are included in lossless compression [11]:

1. Run length encoding
   - Run length encoding
   - Area coding
2. Statistical Coding
   - Huffman encoding
   - LZW (Lempel- Ziv – Welch) coding
   - Arithmetic Coding
3. Predictive Coding

3.1.1. Run length encoding

a. Run length encoding:

The run length encoding(RLE) technique is a very simple compression method used for sequential data. It is the most popular data compression algorithms in which the runs of data i.e. the sequence of similar data elements in the input data stream (repeating string) are replaced by a pair containing the symbol and the run length or the count. The RLE plays a vital role in cases where the data stream contains few and long runs. For any files that do have many runs there is a chance of increase in the file size and hence it is not useful [11]. 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 as shown in figure.1, [13].

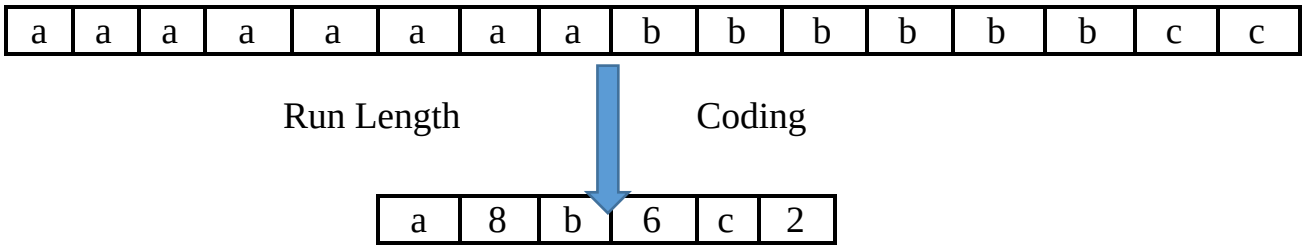

Fig. 1. Run Length Coding

b. 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 [11],[13].

3.1.2. Statistical Coding

a. Huffman coding:

Huffman encoding is a general technique for coding symbols based on their statistical occurrence frequencies [13]. The Huffman code is designed by merging the lowest probable symbols and this process is repeated until only two probabilities of two compound symbols are left and thus a code tree is generated and Huffman codes are obtained from labeling of the code tree [9]. Entropy encoding procedure that is helpful for lossless pressure is called Huffman coding. Huffman built up this technique which is these days used as a "back-end" for different strategies for pressure [10].

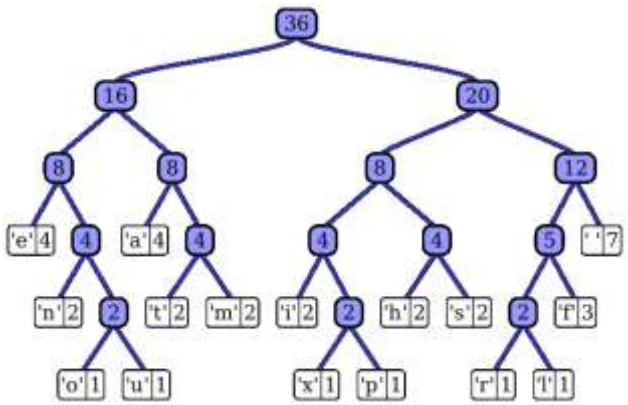

Figure.2. Huffman encoding [13]

b. LZW:

LZW is actually a dictionary-based technique. When a sequence of symbols matches a sequence stored in the

dictionary, an index is sent rather than the symbol sequence itself. If no match is found, the sequence of symbols is sent without being coded and the dictionary is updated [8]. LZW (Lempel–Ziv– Welch) is used in GIF images. Also noteworthy is the LZR (Lempel-Ziv–Renau) algorithm, which serves as the basis for the Zip method. LZ methods use a table-based compression model where table entries are substituted for repeated strings of data. For most LZ methods, this table is generated dynamically from earlier data in the input. The table itself is often Huffman encoded (e.g. SHRI, LZX). A current LZ-based coding scheme that performs well is LZX, used in Microsoft CAB format. The best modern lossless compressors use probabilistic models, such as prediction by partial matching [6].

c. Arithmetic coding:

Arithmetic coding, invented by Jorma Rissanen, and turned into a practical method by Witten, Neal, and Cleary, achieves superior compression to the better-known Huffman algorithm and lends itself especially well to adaptive data compression tasks where the predictions are strongly context-dependent. Arithmetic coding is used in the bi-level image compression standard JBIG, and the document compression standard DjVu. The text entry system Dasher is an inverse arithmetic coder [6]. In Arithmetic coding, code words are constructed by partitioning the range of numbers between zero and one. As each symbol is encoded, the range is decreased by the amount inversely proportional to the probability occurrence of the symbol. When the range is sufficiently narrow, the partitioning is terminated and the codeword is assigned a binary fraction which lies within the final range [8]. In this technique, instead of coding each symbol separately, whole image sequence is coded with a single code. Thus, the correlation on neighboring pixels is exploited. Arithmetic coding is based on the following principle. Given that • The symbol alphabet is finite; • All possible symbols sequences of a given length are finite; • All possible sequences are countable infinite; • The number of real numbers in the interval [0,1] is unaccountably infinite; we can assign a unique subinterval for any given input [11].

3.1.3. Predictive Coding

Predictive Coding Technique constitute another example of exploration of interpixel redundancy, in which the basic idea to encode only the new information in each pixel. This new information is usually defined as the difference between the actual and the predicted value of the pixel. The predictor"s output is rounded to the nearest integer and compared with the actual pixel value: the difference between the two- called prediction error [11].

3.2. Lossy Data Compression

Lossy data compression is the converse of lossless data compression . In these schemes, some loss of information is acceptable. Dropping nonessential detail from the data source can save storage space. Lossy data compression schemes are informed by research on how people perceive the data in question [6].

In lossy image compression, the reconstructed image contains degradation relative to the original. In lossy compression, higher compression can be achieved when compared to lossless compression scheme [12].

There are two plans for lossy constriction: Discrete Cosine Transform, Discrete wavelet Transform [18].

3.2.1. Discrete Cosine Transform (DCT)

DCT is the latest wit change in the picture constriction field due to its astounding properties of vitality compaction. The picture to be changed is isolated into square hinders each piece comprise of n pixels, and each piece is changed into n DCT coefficient. The formula for discrete cosine transform is:

$$F(u) = \frac{2c(u)}{n} \sum_{j=0}^{n-1} f(j) \cos \frac{(2j+1)u\pi}{2 \times n}$$

Where, u=0, 1… n-1

For the backwards change the accompanying one dimensional IDCT is connected two times:

$$f(j) = \sum_{u=0}^{n-1} c(u)\, F(u) \cos \frac{(2j+1)u\pi}{2 \times n}$$

Where, j=0, 1 …n.

DCT coefficients can be achieved by applying DCT on the picture and whole numbers will be quantized by non-whole number DCT coefficients. By and large the estimations of most DCT coefficients are zero or about zero. That implies there are some data misfortune, it happens just during the time spent coefficient quantization. In the profuse instant decennary JPEG picture constriction standard presented in view of DCT.

3.2.2. Discrete Wavelet Transform (DWT)

The DWT speaks to a picture as an entirety of wavelet capacities, known as wavelets, with various area and scale. The discrete wavelet change generally is actualized by utilizing a various levelled channel structure. It is connected to picture squares produced by the pre-processor. JPEG/DCT based constriction has the disadvantages of blackness and associating mutilation in the remade picture at low piece rates. Wavelet change has turned out to be mainstream in picture and video applications since the premise work coordinate the human visual attributes.

Wavelet coding procedures result in subjectively satisfying picture because of the nonattendance of blocking impact and associating twisting, its present another standard for picture pressure JPEG2000 [18].

The DWT of a flag is figured by going it through a progression of channel. The formula for DWT is:

$$\boldsymbol{y(n) = \sum_{k=-\infty}^{\infty} x[k]g[n-k]}$$

In wavelet-based picture coding, the selection of wavelets is critical and decides the coding execution and recreated picture quality [31]. Yoke of wave function includes to any disintegration of a picture into wavelets and this can be characterized as one for the low frequencies or smooth parts of a picture and one to speak to the high frequencies comparing to the definite piece of a picture.

3.2.3. Vector Quantization Compression

Vector Quantization is a lossy pressure strategy. It is employed to-settled length calculation called LBG-VQ calculation. The importance depends on isolating a huge arrangement of information points or vectors into bunches having around a similar number of focuses nearest to them. It works by encoding esteems from a multi-dimensional vector space into a limited arrangement of qualities from a discrete subspace of lower measurement. A lower space vector requires less storage room, so information is compacted. The change is normally done by a Codebook. Vector Quantization is utilized as a part of numerous applications, for example, voice and picture constriction, Voice acknowledgment as illustrated in figure.3, [18].

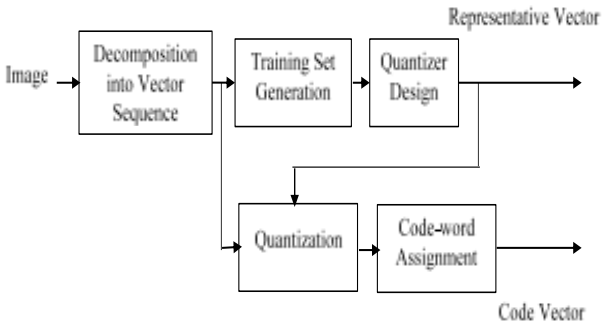

Fig. 3. Vector Quantization Process

3.3. DPCM (Differential Pulse Code Modulation)

(DPCM) is a signal encoder consisting of pulse code modulation (PCM) with added functionalities based on the prediction of the samples of the signal. The input to DPCM may be an analog signal or a digital signal. Since DPCM requires discrete time signal as an input, and if the input is a continuous-time analog signal, then it is required to be sampled first so that a discrete time signal is obtained which is then given to the DPCM encoder. It is an efficient data compression technique, which is useful for reducing transmission rate of digital picture information. The use of DPCM in image coding, however, requires some caution when transmission errors occur, because in the reconstructed DPCM image transmission errors tend to propagate and severely degrade the image quality [11]. (DPCM) method is a typical prediction based technique. Transformation is used to transform the image from the spatial domain into another domain, applying; for example, the discrete cosine transforms (DCT) or the discrete wavelet transform (DWT) [9]. JPEG international compression standard prescribes the use of variable-neighbor-hood DPCM for lossless coding and DCT followed by Huffman coding for lossy coding of still images [2].

IV. IMAGE FORMATS

4.1. JPEG:

JPEG standard includes two basic compression methods, each with various modes of operation. A DCT-based method is specified for “lossy” compression, and a predictive method for “lossless” compression [1]. 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.

JPEG international compression standard prescribes the use of variable-neighbor-hood DPCM for lossless coding and DCT followed by Huffman coding for lossy coding of still images [2]. JPEG standard defines a standard 8×8 quantization table for all images which may not be appropriate [15].

4.2. JPEG2000:

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

4.3. TFII Algorithms:

The TIFF (Tagged Image File Format) is a flexible format which can be used for lossless or lossy Compression .In practice, TIFF is used as a lossless image storage format in

which image compression is not used. For web transmission TIFF files are not used because TIFF files require large size [15].

4.4. 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 colours [15].

V. TECHNIQUES OF IMAGE COMPRESSION

5.1. DCT-Based Image Coding Standard:

JPEG/DCT still image compression has become a standard recently. JPEG is designed for compressing full-color or grayscale images of natural, real world scenes. To exploit this method, an image is first partitioned into non overlapped 8×8 blocks. A discrete Cosine transform (DCT) is applied to each block to convert the gray levels of pixels in the spatial domain into coefficients in the frequency domain. The coefficients are normalized by different scales according to the quantization table provided by the JPEG standard conducted by some psycho visual evidence. The quantized coefficients are rearranged in an order to be further compressed by an efficient lossless coding strategy such as run length coding, arithmetic coding, or Huffman coding. The information loss occurs only in the process of coefficient quantization. The JPEG standard defines a standard 8×8 quantization table for all images which may not be appropriate. To achieve a better decoding quality of various images with the same compression by using the DCT approach, an adaptive quantization table may be used instead of using the standard quantization [15].

5.2. Wavelet Coding Techniques (WCT):

The wavelet coding techniques is based on the idea that the co-efficient of a transform that decor relates the pixels of an image can be coded more efficiently than the original pixels themselves. If the transform's basis functions in this case wavelet- packs most of the important visual information into small number of co-efficient, the remaining co-efficient can be coarsely quantized or truncated to zero with little image distortion.

VI. CONCLUSION:

An overview of lossless and lossy image compression techniques carried out by previous researchers is presented.

Data compression a popular approach to reducing data volumes to lower disk utilization and reduce network traffic and data transfer times in distributed computing. The review paper is presented some significant of using data compression in networking as well as different types of image compression techniques. Lossless and lossy are major techniques of image compression methods. Furthermore, the review explored the types of image format such as jpeg, tiff, bmp, png, included algorithms for each format, and the methods and salient features are described in details such as transform coding, Huffman coding, Arithmetic Coding, medical image coding Entropy coding, JPEG, JPEG 2000, LZW and DPCM.

REFERENCES

[1]. Wallace, G. K., The JPEG Still Picture Compression Standard, IEEE Transactions on Consumer Electronics , 1992
[2]. Strintzis, M. G., A review of compression methods for medical images in PACS, 1998
[3]. Kannan, E. & Murugan, G., Lossless Image Compression Algorithm For Transmitting Over Low Bandwidth Line, 2012
[4]. PAINTER AND SPANIAS: PERCEPTUAL CODING OF DIGITAL AUDIO, 2000
[5]. Koff, D. A & Shulman, H., An Overview of Digital Compression of Medical Images: Can We Use Lossy Image Compression in Radiology?, 2006
[6]. Kallat, G. & Yogeshwaran, A., HYPERSPECTRAL IMAGE COMPRESSION USING DUAL-TREE BEZW ALGORITHM , 2015
[7]. Devadason, J. R., Image Compression for Mobile Devices using Prediction and Direct Coding Approach, 2015
[8]. Ravula, V., LOSSLESS IMAGE COMPRESSION AND WATERMARKING, 2017
[9]. Dubey, S., A Combine Approach of Compression And Encryption For Image Transmission, 2014
[10]. Kanchanadevi, B. & Tamilselvi, P.R, A SURVEY ON MEDICAL IMAGE PROCESSING AND COMPRESSION TECHNIQUES, 2017
[11]. Garba, A., Jauro, A. I., Bala, A., A STUDY ON IMAGE COMPRESSION TECHNIQUES, 2016
[12]. Vidhya, K., Karthikeyan, G., Divakar, P. & Ezhumalai, S., A Review of lossless and lossy image compression techniques, 2016
[13]. Jindal, R., A Review on Recent Development of Image Compression Techniques, 2017
[14]. Pati, P., Pati, S.V. & Chaudhari, D. D., Research on Conversion of DICOM Multi-Frame Medical Image in to Multimedia Format using MATLAB, 2015
[15]. Kaur, S., A REVIEW PAPER ON IMAGE COMPRESSION TECHNIQUES, 2016
[16]. Zhang, J., You, S. & Gruenwald, L., Quadtree-Based Lightweight Data Compression for Large-Scale Geospatial Rasters on Multi-Core CPUs,
[17]. Sayood, K., Data Compression, Encyclopedia of Information Systems, 2003
[18]. Shadi, M.S. & Hossain, M.A, Classification on Image Compression Methods: Review Paper, 2018.