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EVALUATION OF IMAGE COMPRESSION TECHNIQUES: AN IMPLEMENTATION OF TRUE COMPRESSION ON 2-D IMAGE

*Nageen Fatima[1], Sadia Murawwat[1] and Syeda Ameena Rizvi[1]

[1]Department of Electrical Engineering, Lahore College for Women University, LHR

*Corresponding author: engineernageen123@gmail.com

ABSTRACT

Image compression, an application of data compression, widely use in advance multimedia, communication and graphical systems is used to minimize storage requirements and transmission cost. It increases transmission rate by decreasing redundancy of image data in either lossy or lossless compression means. In this research work, comparison of compression techniques is done using Compression Ratio (CR) and Bit-Per-Pixel (BPP) ratio as performance parameters. Image compression by Huffman encoding, Embedded Zero tree Wavelet (EZW) and Set Partitioning in Hierarchical Trees (SPINT) technique is performed. The result showed that lossy techniques are reliable to save hardware memory consumption but having low CR ratio. In lossless techniques, CR ratio is higher and it uses more space to store compressed image. Proposed comparison between lossy and lossless techniques is supportive in choosing an optimal technique for image compression and facilitates the process of an efficient compression.

Keywords: Image compression, compression techniques, redundancy, CR, BPP, Huffman coding, SPINT.

1. INTRODUCTION

Image is a pictorial representation of signals usually analog in nature and converted into digital for further processing. It contains huge amount of data for storage and transmission while conversion. The aim of image compressionis to minimize storage space and data required fordepiction of digital image. The compressed image represented by less number of bits and required less space for storage without affecting its quality. This technique has become more reliable for reducing memory allocation of hardware and transmission bandwidth (Hussain *et al*., 2018).

Nowadays use of image compression become frequent due to its simplicity, adaptiveness, advancement and applications of multimedia products (Logashanmugam *et al*., 2008). It does not reduce the physical size of an image but also compresses the bits that make up the image into a smaller size. It also decreases the time required for image to be sent over the transmission channel and help users by loading pictures faster and web-pages to use less space on a web host.

1.1 Image Coding System

Coding system of image consists of following stages: Input signal processed in three ways as: mapper for conversion of image into inters pixel coefficients by Discrete Cosine Transform (DCT) and wavelet transform. Next is quantizer used to reduce the number of bits needed to store the transformed coefficients and a lossy process. Then encoder is used for compressed quantized coefficients and improves compression by removing code redundancies (Chawla *et al*., 2014).

Decompression is done by reverse process of compression by using decoder, dequantizer and inverse mapper to get reconstructed image.

1.2 Types of Image Compression

Image compression is divided into two categories lossy and lossless. These categories are further divided into following encoding techniques (figure 2).Lossy compression technique is especially used for natural images whereas lossless technique is suitable for artificial images (Ravi *et al*., 2015).There are some encoding techniques of lossy and lossless compressionas given below:

- *Transform Encoding:* It isuses to transform Discrete Fourier Transform (DFT), Discrete Sine Transform (DST) and DCT to change the pixel specifications form spatial domain to frequency domain (Rojatkar *et al*., 2015).
- *Vector Quantization Encoding:* It is a generalized scaler quantization technique uses to reduce pixel values. It is an optimal approximation from input space to output space. The goal of vector quantization is to reduce the bit rate and to minimize channel capacity (Gray *et al*., 1994).
- *Fractal Encoding:* This technique relies on the fact that in an image, some parts of it resemble other parts of the same image. Fractal code converts these parts into mathematical data used to recreate the encoded image (Arora *et al*., 2014).
- *Block Truncation Encoding:* In this technique image is divided into blocks and quantizer is used to reduce the number of gray levels in each block. Every block has same mean and standard deviation.
- *Runlength Encoding:*It is a lossless data compression technique in which data is in the form of runs. Runs are the sequence of same data values occur in consecutive data elements and stored as a single value rather than as the original run (Arora *et al*., 2014).
- *ArithmeticEncoding:*This technique is independent of characteristics of medium and a variable length coding process uses to reduce the redundancy of code. It works only when all symbols probabilities are an integral power of 0.5 (Clarke *et al*., 1996).
- *Predictive Encoding:*It predicts the next pixel value based on sequence of previous values obtained throughout the scanning of image and encodes the difference between predictive and actual value (Umbaugh *et al*., 2005).
- *Huffman Encoding:* It is one of the oldest image compression methods and is used to reduce coding redundancy without degrading the quality of reconstructed image. It uses a known probability distribution to assign variable length code-words (Hussain *et al*., 2018).

Detailed discussions of these encoding techniques are given in third section.

2. MATERIALS AND METHODS

The motive of this research paper is to show different techniques for a true color or a grayscale image for compression.MATLAB (2015a) is used for analyzing CR and BPP of an image whereas wavelet transform and Huffman encoding algorithm applied on an image for compression.

Basic concept of image compression in MATLAB for both true colour and grey-scale images is shown in figure 3.

2.1 Algorithm:

- Load and display input image in grey-scale.
- Calculate CR and BPP by using Huffman encoding.
- If BPP < threshold of grey-scale or true-colour image
- Applied decompression technique
- Else

- Load image again
- Apply compression technique on image by using wavelet transformation or SPIHT
- Compare it with original image and repeat these steps until compressed image got maximum percentage of CR ratio.

First step is conversion of original image into grey-scale image (Figure 4) where initial BPP and CR ratios of image were0.38 and 1.57% respectively. But these values became 0.06 and 0.25% in 8th iteration of loop and then0.60 and 2.51% at 11th iteration of loop (Figure 5). At the completion of compression coding, the final integral values of BPP and CR ratio are 1.46 and 6.07% in 14th iteration of loop (Figure 6). The results are acceptable for storage and communication purpose while keeping a good visual observation.

3. RESULTS AND DISCUSSION

Lossy techniques are used where loss in information of image is tolerable like audio and still images. Whereas loss of slight information in real time signals, biomedical signals and text articles in not tolerable. For such type of applications lossless compression techniques are preferred. The detailed discussion of these techniques is given below;

3.1 Lossy Compression Techniques

In lossy compression, the reconstructed image contains degradations relative to the original image. It has higher compression ratio but with less image quality (Chen *et al*., 2003).

3.1.1 Transform Encoding

Conversion of data into a form in which compression is easier is the main purpose of transformation. This transformation will transform the pixels which are correlated into a representation where they are decorrelated. As a result of transformation, smaller new values on average are experienced than the original values. The net effect is to minimize the redundancy of representation (Rojatkar *et al*., 2015). For lossy compression, the transform coefficients can now be quantized according to their statistical properties, producing a much compressed representation of the original image data.

3.1.2 Vector Quantization Encoding

Vector quantization is the most powerful and quantization technique which is used for the image compression. In speech and image signal, vector quantization algorithms have been extensively used for reducing the transmission bit rate or storage. Image vector quantization (VQ) consists of four stages: vector formation, Training set selection, codebook generation and quantization (Mittal *et al.,* 2013). First step is the division of input image into set of vectors . By an iterative clustering algorithm, code words for codebook are obtained. For quantizing an input vector, from codebook, closest code words have been determined and parallel label of this code word has been processed. In such way, data compression is obtained as address transmission requires fewer bits than transmitting vector itself.

3.1.3 Fractal Encoding

Fractal coding is a potential image compression method, which is based on the ground breaking work of Barnsley and was developed to a usable state by Jacquin (Barnsley *et al.,* 1985). Because of its potential high compression ratio, fast decompression and multi resolution properties it is a potential image compression scheme. Fractal image compression utilizes the existence of self-symmetry of images.

3.1.4 Block Truncation Encoding

Block Truncation Coding (BTC) is introduced by Delp and Mitchell, is a simple lossy image compression technique used to compress monochrome image data (Delp*et al.,* 1979). It achieves 2 BPP with low computational complexity. In this algorithm, first and second order moments are preserved in each image block (Saua *et al.,* 2013). To decrease the demand of storage space and to get the image of acceptable quality, BTC is used to perform moment preserving quantization for each non overlapping block of pixels.

3.2 Lossless Techniques

In lossless compression, for each pixel there is contrast between the reconstructed image and original image. It has less compression ratio but the quality of compressed image is good. (Saua*et al.,* 2013)

3.2.1 Runlength Encoding

Run length counts adjacent pixels of same gray level value called the run-length, which is encoded and stored. When image is compressed by block transformation, Run length coding is the standard coding technique for compressing the images (Kitty Arora *et al*., 2014). RUN denotes the number of repeated zeros and appends the non-zero coefficient which is represented as LEVEL following the sequence of zeros.

3.2.2 Arithmetic Encoding

A sequence of bits to a message, a sting of symbols has been appointed by Arithmetic encoding (Abdmouleh *el at.,* 2012). Arithmetic coding can treat the whole symbols in a list or in a message as one unit. It doesn´t use a discrete number of bits for each. The number of bits used to encode each symbol depends on probability assigned to that symbol. Low probability symbols use more bits as compared to high probability symbols. The main concept behind Arithmetic coding is to assign each symbol an interval.

3.2.3 Predictive Encoding

For lossless image compression, Predictive coding is effective one. With the help of pixel color values of neighboring pixels, Predictive coding estimates a pixel color value (Pensiri *et al.,* 2012). Differential Pulse Code Modulation (DPCM) is generic compression technique used to describe predictive coding. This method works by transmitting the difference of a pixel and its prediction instead of direct transmission of pixel's value.

3.2.4 Huffman Encoding

Huffman coding is classical data compression techniques invented by David Huffman. Result of this method gives unequal code (variable length), where the size of code words can vary. In case of complex images, Huffman coding lessen the file by 10% to 50% (1.1:1 to 1.5:1), but by preprocessing of irrelevant information removal this ratio can be improved to 2:1 or 3:1. It consists of optimal prefix code which is generated from set of probabilities and has been used in various compression applications. These codes are of variable code length using integral number of bits (Kumar *et al.,* 2014). The compression process is based on building a binary tree that holds all symbols in the source at its leaf nodes and with their corresponding probabilities at the side. The summaries of above discussed techniques are given in table 1 for lossy and for lossless compression techniques (Table 2).

CONCLUSION

This paper reviews different lossy and lossless compression techniques with possible pros and cons. The demand of image compression increased rapidly and used in digital image processing for commercial applications. For understanding the phenomena of compression, an image is compressed to get desired copy of original image which contain lesser size for memory storage. These techniques shave certain limitations to use over different type of images as: audio, static images, real-time signals, biomedical signals etc. For audio and still images lossy techniques are preferable and for biomedical signals or text information lossless techniques are superior. At the end, concluded that lossy techniques have low compression ratio but reduce the size of image to save hardware memory consumption. On the other hand, lossless techniques have better compression ratio but using more space to store compressed image as compare to the original image. The anticipated comparison is helpful to choose optimal technique for image compression.

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Table 1: Lossy Compression Techniques

Technique	**Pros**	**Cons**
Transform Encoding (S.Thayammal*et al*., 2013)	• Easily implemented for real time data. • Improve CR ae well as Peak signal-to-noise Ratio (PSNR)	• High computational complexity. • Consume more storage of hardware
Vector Quantization Encoding (G. Boopathy*et al*., 2010)	• Extends scaler quantization to higher dimensional space. • Higher performance ratio	• Compression time is higher • Not suitable for real time signals • Lower bit rate • Needs large storage size
Fractal Encoding (Mitchell Douglass*et al*., 2016)	• Fast decoding time • Descent compression ratio • Resolution independent	• Slow encoding time • Susceptible to pathological cases
Block Truncation Encoding (S. Rahul *et al*., 2016)	• Simple, fast, lossy and fix length compression technique • Reconstruct image into high quality • Low computational complexity • Consume less space for storage	• Low bit rate cause wrong contouring • Low compression ratio

Table 2: Lossy Compression Techniques

Technique	Pros	Cons
Runlength Encoding (Athira B *et al*., 2013)	• Simplest image compression technique • Use for sequential and repetitive data	• Convert bi-level images into grey-scale image • Not a good compression technique for complex images • Low compression ratio
Arithmetic Encoding (S. Lakshmi *et al*., 2013)	• Batter coding efficiency • Reduce coding redundancy	• Poor error resistance • Unable to decode until all bits of a message received.
Predictive Encoding (A.J. Hussain *et al*., 2018)	• Non-linear predictor provides batter coding and correlation among the image pixels. • Used for 1-D as well as 2-D signals.	• Low compression ratio • Needs sensitive predictor structure
Huffman Encoding (A.J. Hussain *et al*., 2018)	• Batter PSNR ratio • Frequently applicable on JPEG image	• Slower than other techniques • Optimal for known probability distributions only

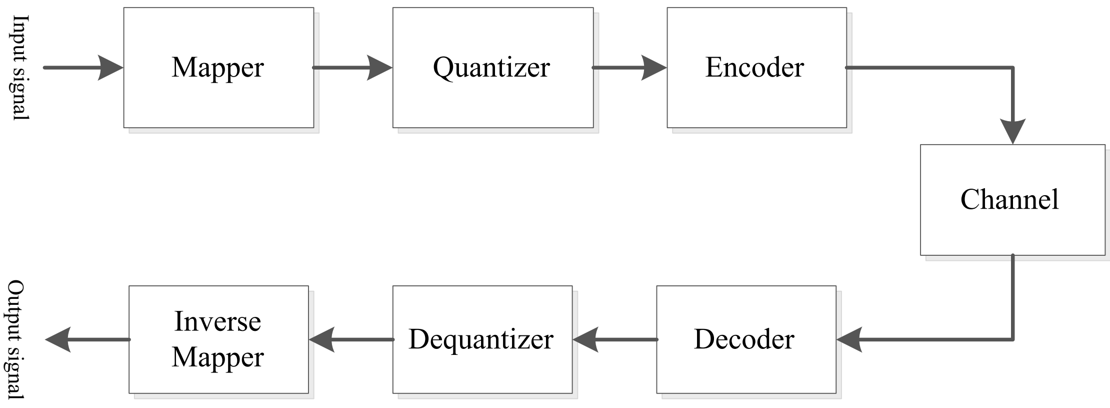

Figure 1: Block diagram of Compression Decompression

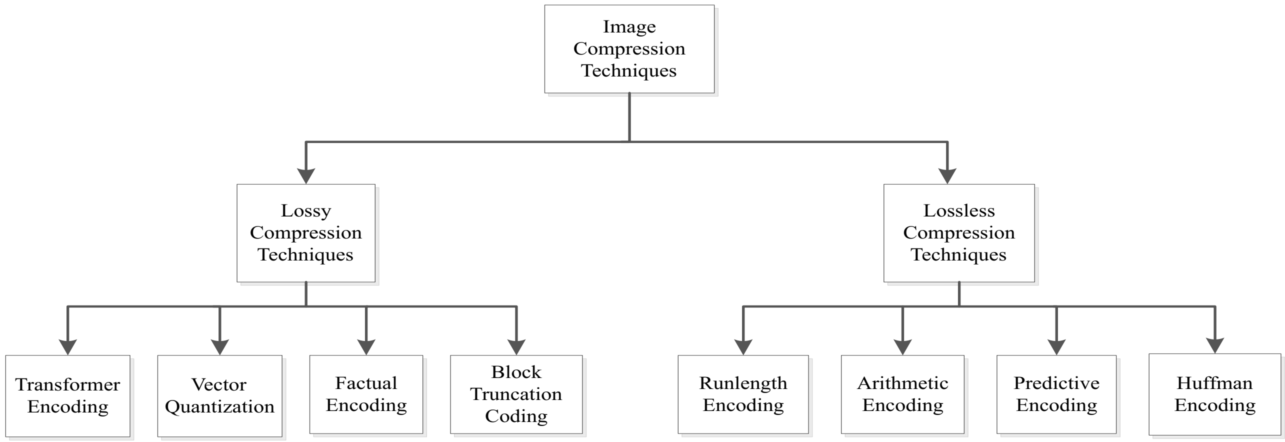

Figure 2: Types of Image Compression Techniques

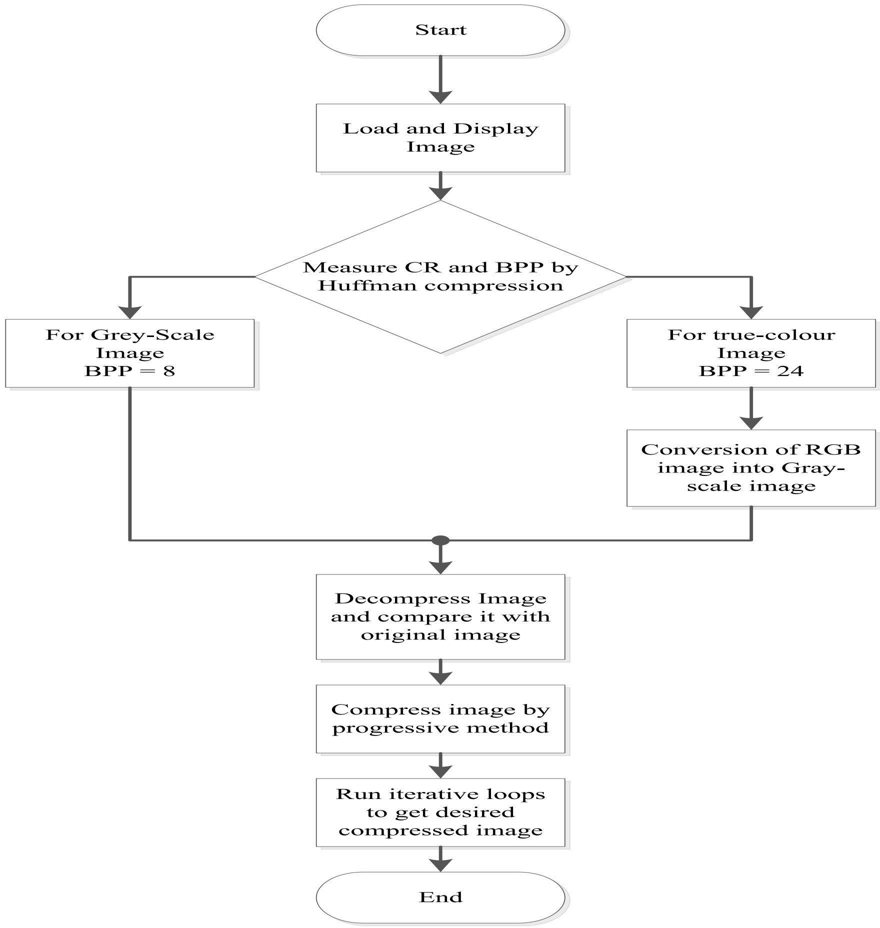

Figure 3: Image Compression in MATLAB

Figure 4: Conversion of image into grey-scale