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Research paper

Comparative Study of Lossy and Lossless Image Compression Techniques

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Abstract

In the current world of computer networks and storage media processing on digital images has been increased. It consumes large volume of bits to process and its storage. To deals with these challenges, compression plays a major role in the data of animage is transmitted through the internet fast and consume sufficient memory for its storage. In this paper, different types of lossless and Lossy image compression techniques are discussed with experimental results. Lossless compression encodes and decodes the data without damaging/no information loss whereas Lossycompression achieves high compression with acceptable loss of information. It services on various applications like military, business, industry, education, social media and application. The reports of their works are compared by applying the standard performance measures of Mean square Error and Peak Signal to Noise Ratio.

Keywords:*Lossless and Lossy image compression, Spatial and Frequency domain image compression, Encoding techniques and Quantization*

1. Introduction

A digital data performs a main role in internet market of the world. It consumes more storagespace to store the information and cost is very high when it is transmitted in internet channel. To better transmission and storage, the data storage of the image is minimized by removing redundancy data or unwanted data. The main role of the image compression is to minimize the storage of an image with acceptable loss of image quality. It involves two parts that are encoding and decoding. In encoding, the original pixels are treated to encode and changed as binary bits whereas, in decoding, the output bits of encoded is applies same to decode and converted into getting original pixels that are decoded the image. Generally, the image compression process either in spatial domain [1-3] or frequency domain [4, 5]. Compared to normal text, distribution of image data carries much amount of data. Compressing digital image is needed for sending via the network channel and storage purpose. Frequency domain based compression is performed well in compressed ratio. More compression ration achieves speed transmission and better storage than compared to a spatial domain. Processing power of computers that send digital images among the network and computation are high in a frequency domain compression. Spatial domain based compression is preferred in that case. When compared with frequency, spatial has less computation. In order to increase the compression ratio, it preserves either the lossless or less visual quality of image. In image compression, quality is a main concern. The techniques which involved in lossless compression without affecting quality of image for both domains are reported in [6-9]. Another criterion in image compression reduce the psycho visual redundant data is called as Lossy compression [8, 9]. It achieves huge compression ratio when comparing to lossless compression. It accepts and compromises the reduction of image quality. Sometimes it leads to critical issue in some area like the satellite image, bio medical image, and medical field. Nowadays all the smart devices, tablets and computers are growing day by day and it accesses such imaging fields in orderto the advancement in the network topology. So that it does not accept the information loss in decoded images by applying simple algorithm which takes low computational complexity.
The remaining part in this paper are explained as follows. Background study of Lossy and lossless image compression techniques are described in Section II. Section III reports about performance measures to compute and observe the compression algorithms. Performance of various compression algorithm with various images are described and the outcomes are reported in Section IV. Finally, conclusion in section V.

2. Lossless and Lossy Image Compression

There are two types of Image compression: Lossless compression and Lossy compression. There is no information is lost during lossless compression whereas in Lossy which accept the loss of information that are measured by performance measures. The various methods used in lossless are transform coding, quantization and Block truncation coding.

2.1. Transform Coding

The original pixels of image are directly applied to transform coding in which the giveninputcolor image (RGB) is converted into YCbCr image then transform is applied. The usage of transform coding is to shorten the correlation between the pixels in which less amount of bits is enough to allocate to each transform coefficient value. Some of popular transformations in image compression consists of Fourier Transformation [10], Hadamard Transformation [11], and Discrete Cosine Transformation [12-14]. The block based transformations divides the image into sub-blocks with a standard window size of 8x8. For many images, large energy values of pixels lie at the low frequency component which is presented in top left corner of each sub block. The presence of bottom top right corner coefficients holds low energy value. To minimize the transformed values, it increases the compression ratio (CR). Discrete Wavelet transformation [15, 16] processes on image with high compression ratio and good quality of reconstructed image while reconstructing image than compared to DCT.

2.2. Quantization

A technique involved in Lossy compression which is widely used to achieve huge compression ratio. The compression ratio is varied based on quality factor. It helps to minimize the required bits to transformedcoefficients by reducing its quantity. It takes round off in where the information is lost. Quantization is of two types that are scalar quantization and vector quantization. In scalar quantization[4,5,15,16], individual coefficient is treated to generate the output whereas in vector quantization, all the coefficients are combined together as single one and form the vector code which are kept in vector code book. Each vector code book is assigned an index. It achieves much compression ratio (CR) while comparing to scalar quantization [17, 21].

2.3. Huffman Coding

It is lossless compression, which assigns code word with minimum length for each quantized transformed coefficient based on its frequency occurrence whereas in Huffman coding, each source element does not depend others and are identical so that it gives optimal coding [4, 5, and 18]. Merits of the work are, assign a lower number of bits to lower frequency and assign a higher amount of bits to higher frequency coefficients. Code words is kept in Huffman codebook table which is referred in decodable part.
Steps involved in Huffman encoding algorithm are reported below:
Input: Quantized transformed coefficients
Output: Encoded bit stream
Step1: Find out the probability of each source element
Step2: Based on the probabilities of these symbols arranged in descending order in which each symbol is considered as leaf node
Step3: To make internal node by adding the last two nodes that act as new leaf for next one. The probability among two leaf nodes are added then assign to internal node.
Step4: Repeat the step 2 and step 3 till a tree is formed
The Prefix code is formed and assigned to each source symbol. Even it produces the optimal result and achieves compression, the next level of Huffman is introduced which produces much compression ratio in CRand also provides good quality of decoded imagein PSNR.

2.4. Arithmetic Coding

The popularlossless technique is widely used in more applications. It gives more efficient slightly than Huffman but it is hard to implement. Arithmetic coding does not allocate bits for all the source symbol. Bits are allocated to each symbol in encoding process that varies to their probability. Low probability source symbols are assigned with many bits and fewer bits are assigned to the high probability source symbols [19, 20]. When compare with other coders, arithmetic coder covers the entire source symbols then converts into a single value. Merit of arithmetic coders is to produce near-optimal resultant value to any given set of input values and their probabilities. Even it takes huge time for computation to implement than compare to Huffman coder; it produces the optimal reconstructed value which reflects on image. So that, it achieves good quality of decoded image. Experimental results shows that CR of the arithmetic coding is better than Huffman. According to coding implementation, Huffman coder takes lowest computation time than arithmetic coding.

2.5. Run Length Coding

A popular lossless compression coding techniques in both JPEG and JPEG 2000 image compression [22]. After applying quantization, the sequence of transformed coefficients consists redundant values so that it increases the number of bits value to represents these transformed values and increases the storage of memory stack and performance degradation. To deal with this problem, the run-length encoding techniques are used in image compression is to improve the compression ratio without degradation of performance.

3.Performance Measure

The standard performancemeasure of image compression is Mean Square Error (MSE) and PSNR values. Mean Square Error is denoted as the average of the squared error among the original and reconstructed image. Lesser value of resultant MSE gives the minimum error so the maximum resultant value of MSE lost the information that gives a maximum error. MSE is calculated as,

$$\mathrm{MSE} = \frac{\sum_{M,N}[I_1(m,n)-I_2(m,n)]^2}{M*N} \quad (13)$$

Where I1 (m, n) denotes the pixel values at the index of (m, n) andI2 (m, n) represents the resultant image respect of I1 (m, n). M and N are the rows and columns innon-squaredimages, respectively whereas in the square image, m and n are equal (m, m). After reconstruct, image in reverse process, the quality measure is computed among the original and the resultant image by using MSE and Peak signal-to-noise ratio (PSNR). PSNR with high value gives good quality of decoded image.

$$\mathrm{PSNR} = 10\log_{10}\left(\frac{R^2}{MSE}\right) \quad (14)$$

Where R denotes peak signal level for a grayscale image, which is takes 255 and MSE is the Mean Square Error.

4.Experiments And Results

In this part, the different encoder techniques like Huffman encoding and Arithmetic encoder with different quantization values has been tested in different monochrome images of different types. Two sample images viz. Lena image and baboon images with size of (256 x 256), are presented in Fig 1(a) and fig 1(b) respectively. The original images are splitted into non-overlapping (8x8) regions and are applied with the transformations like discrete cosine transform and wavelet transformation. Quantization with different quality factors is allocated to each sub block of transformed coefficients. In Huffman, the DC coefficients are treated to Difference Pulse Code Modulation (DPCM) process. Finally, all the coefficients of each blocks are converted into bit stream by applying above mentioned encoding techniques.
The sample experiments are reported for different quality factors by using various encoding techniques below. Under analysis, when quality factor is increased, it is observed that the loss of information of decoded image is higher. The comparison ofPSNR for Lena image and Baboon image with Huffman and Arithmetic coder is shown in fig.2 and 3.Comparison ratio of CR % and PSNR for Lena and Baboon is shown in Fig. 4 to Fig.7.

Fig. 1: Original images (a) Lena and (b) Baboon image

(a) (b)

Fig. 2: Test images with Huffman (a) Lena and (b) Baboon image

(a) (b)

Fig. 3: Test images with Arithmetic (a) Lena and (b) Baboon image

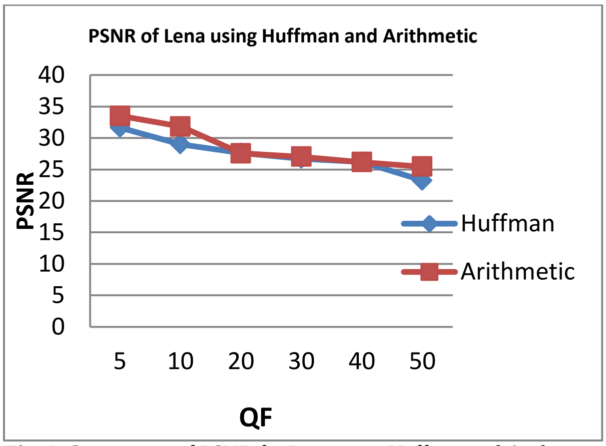

Fig. 4: Comparison of PSNR for Lena using Huffman and Arithmetic

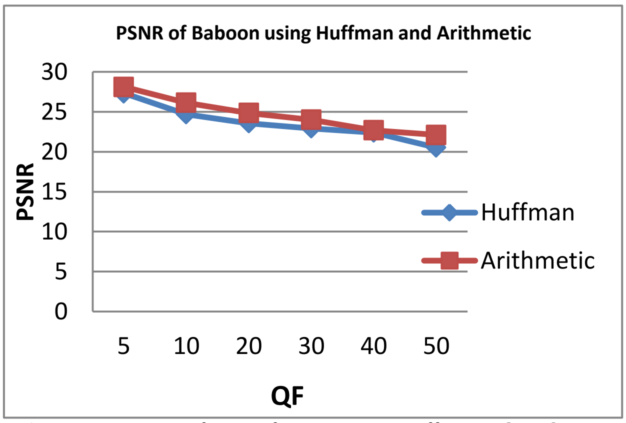

Fig. 5: Comparison of PSNR for Lena using Huffman and Arithmetic

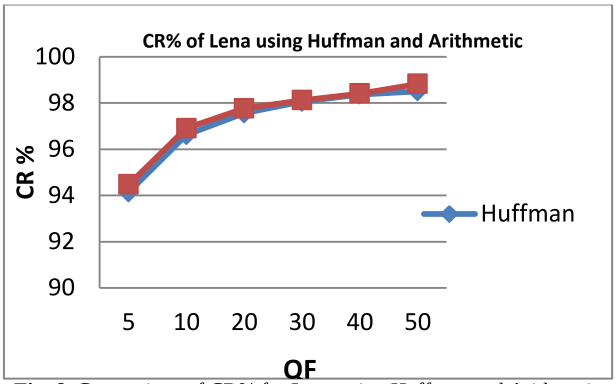

Fig. 6: Comparison of CR% for Lena using Huffman and Arithmetic

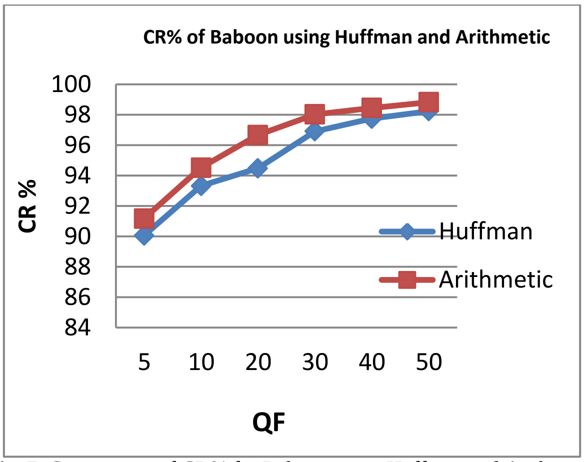

Fig. 7: Comparison of CR% for Baboon using Huffman and Arithmetic

5.Conclusion

This paper consists, a various Lossy and lossless compression techniques with DCT and DWT are reported along with experimental results. According to results, DWT based arithmetic provides good results of CR and PSNR for input images than compares to DCT based Arithmetic and DCT based Huffman Coder. Based on the results of computation time, Arithmetic takes much time than compared to Huffman coder. The quality factor is increased that reduces quality of reconstructed image. Still, the most challenge of image compression is to achieve very huge compression ratio with less degradation in the quality of reconstructed image.

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