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A Comparative Study of Image Compression Techniques

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Abstract:** In this rapidly evolving scenario images areused to transfer more information from sender to receiver rather than large text files as images are the most appropriate medium to send data from one to anotherbut the size of an image creates some issue while sending it to the receiver due to low bandwidth channel and an image also contains more bits to represent it so image compression technique is used to reduce the required amount of bits to represent an image and size of image to pass it to the end receiver without losing the quality and information of it. Sometimes it may be possible that for storing images we need large amount of storage therefore compression decreases the storage quantity needed by an image and can be utilized efficiently. In this review paper different compression algorithms i.e. Huffman coding, Run length coding (RLC) and DWT are implemented and analysed based upon compression ratio, peak signal to noise (PSNR) and mean square ratio (MSE).

***Keywords:** Image Compression, techniques, Huffman Coding, Run Length Coding (RLC), DWT, PSNR, MSE.*

I. INTRODUCTION

An Image contains huge amount of data and needs large quantity of storage to be stored in memory and have more number of bits per pixel to its representation, so Image compression technique is used for reducing the size of an image up to a certain extent. Sometimes while compressing an image it may be possible that data could be lost or not, because it all depends upon the techniques which we are using to compress an image. Image compression is needed so that we can store more number of images in less storage space as well as it contains less number of bits to represent an image as it eliminates the redundant data from an image. Compression technique is quite different from zipping process of a file. It provides the feasibility to transfer more images in low bandwidth channel.Image compression approach rearranges all the bits to a particular compression level and decreases the transmission time. Image compression can be categorized into two classes i.e. lossless and lossy image compression. Each compression techniques has its own advantages. Here we are implementing Huffman Coding, Run length coding (RLC), DWT (Discrete wavelength transform).The Major concern of image compression is to deduct the quantity of data which is essential for representing the sampled discrete images and thus reduce the cost of memory space and communication.

The fundamental basic model of Image Compression can be shown as in figure 1. The original image is given as an input and then the redundant information can be removed from it by implementing some algorithms and a reconstructed image if generated as a output.

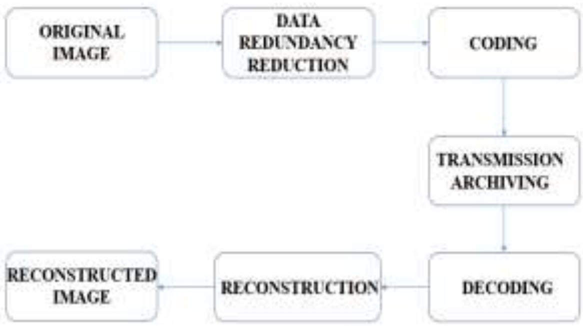

Fig. 1. Image Compression Fundamental Model

II. IMAGE COMPRESSION TECHNIQUES

In image compression process it might be possible that the data in an image can be lost or not. Based on this image compression can be categorized into two classes as shown in figure 2.

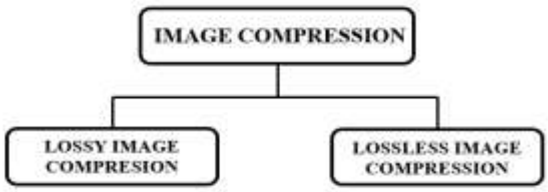

Fig 2. Image Compression Techniques

A. Lossy Image Compression: In lossy image compression some information of image could be lost while compression process takes place. It is also known as irreversible image compression as it uses some inexact partial data discarding approach to represent an image.

B. Lossless Image Compression: In lossless image compression technique the original image can be reconstructed by using the compressed image. Lossless image compression is mandatory when it is required that the original and compressed image are equivalent.

Lossless image compression improves the compression ratio. It uses three different algorithms for under its structurefor compressing an image: -

1. Huffman Coding Algorithm
2. Run Length Coding Algorithm
3. DWT (Discrete Wavelet Transform) Algorithm

1. Huffman Coding Algorithm:

Huffman coding Algorithm is a lossless compression algorithm proposed by David Huffman in 1952. It was a first compression technique based upon Shannon's information theory. It is an entropy based compression algorithm that depends upon the analysis of the frequency of each symbol in an array. This approach identifies the relative frequency of all the character symbols. The analysis of these frequencies of symbols is used to create a Tree library. Those two frequencies that contains least values are added to create an initial tree library. As soon as tree library is assembled then it could be loaded into a lookup table in both entities i.e. receiver and sender. It is a feasible and efficient algorithm to implement compression operation at particular limit. Huffman coding is generally used in text, image and video compression. It reduces the image size by 10 % – 50% by eliminating the duplicate data. This process works by making a binary tree of symbols. It can be stored in a regular array and the size of which depends on the number of symbols (N).

In this coding technique each pixel is assume to be a symbol.

Those symbols that have large amount of frequencies must assign a low level of bits whereas the symbol that consists less frequency will be assigned small number of bits.

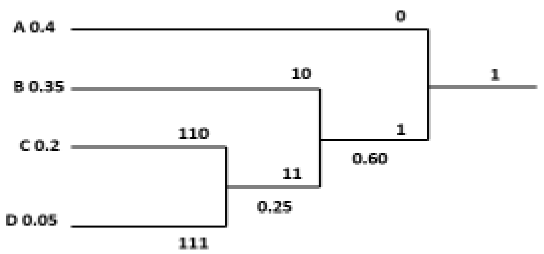

Fig. 3. Huffman Coding

Suppose we have a source generating 4 different symbols {A, B, C, D} with probability {0.4, 0.35, 0.2, and 0.05}. Make a binary tree from left side to right side by taking the two smallest symbols that contains less frequencies, add themto form another equivalent symbol. Repeat the same process unless you have a single symbol remaining, then starts backtracking, from right direction to left direction, by assigning different bits to different branches.

Huffman coding requires more amount of memory, lookup table, and library which increase the overall cost of the system.

The final Huffman code is:

Symbol	Code
A	0
B	10
C	111
D	110

Fig. 4. Huffman Codes

2. Run Length Encoding Algorithm:

Run Length Encoding Algorithm is very general form of lossless image compression. It uses runs of data to be stored in a single unit. Run length encoding is useful when the image contains repeated data. If we have a particular sequence of same intensity pixels or symbols then run length encodes them into a smaller symbols. The smaller symbols are represented by an sequence i.e. (P_i, R_i) where $P_i$is intensity of that pixel and $R_i$is the number of same intensity pixels. The repeated intensities along with their rows can be represented by runs of identical intensities as Run-length pairs.

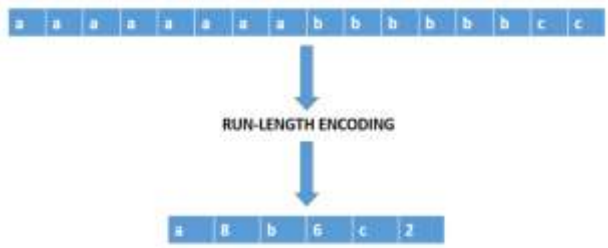

Fig. 5. Run-Length Encoding Algorithm

3. DWT Algorithm:

Lossless image compression also consist of Discrete Wavelet Transform. To convert the discrete time signal to discrete wavelet representation so that it gives multi-resolution, this can be attain by using discrete wavelet transform. This coding algorithm minimize the blurring and noise of an image. It is used in several processing applications such as edge detection, noise reduction etc. The DWT can do a systematic decomposition of signals into lower resolutions. DWT is observed as continuous high -pass and Low-pass filtering of discrete time domain signal. In an image of two dimension, which is generally taken as matrix of M rows and N columns. An image in wavelet transform consist of two parts—

1. Lower frequency of an image

2. Higher frequency of an image.

As shown in figure 6. The wavelet filter decomposition of an image have four dissimilar sub-images; the approximation (LL), he vertical detail (LH), the horizontal detail (HL), the diagonal detail (HH)

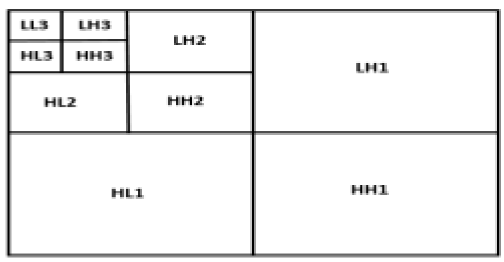

Fig. 6. Wavelet Filter Decomposition

III. PERFORMANCE PARAMETERS

To check the quality of a compressed image there are certain parameters. The frequently used parameters are

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CR (Compression Ratio), PSNR (peak Signal to Noise Ratio) and MSE (Mean Square Error).

A. Compression Ratio (CR):

It is the ratio between size of original Image and size of Compressed image.

$$CR = \frac{Size\ of\ Original\ Image}{Zise\ of\ Compressed\ Image}$$

B. Mean Square Error (MSE):

In this parameter we check the quality of a compressed image. The quality of a compressed image is good if the value of mean square error is less and vice-versa. The formula of MSE is:

$$MSE = \frac{1}{PN}\sum_{x=1}^{p}\sum_{y=1}^{N}[f(x,y) - f'(x,y)]^2$$

Here f(x, y) = Original image

f'(x, y) = compressed image

P, N = Image dimensions

C. Peak Signal To Noise Ratio(PSNR):W

The peak Signal to noise ratio is define as the ratio between size of original image to the square of mean square ratio (MSE). The quality of compressed image is considered good if PSNR value is high.

$$PSNR = \frac{10\log_{10}[M * N]}{[MSE^2]}$$

IV. RESULT

The following results are obtained by experimenting inMATLAB 2014A.

Fig. 7. Original Image (Input Image)

Fig. 8. Compression of Original Image using Huffman Coding

Fig. 9. Compression of Original Image using RLE Coding

Fig. 10. Compression of Original Image using DWT Coding

Table 1. Different Parameter of Huffman Coding

Algorithm	Huffman Coding		
Parameters	**CR**	**PSNR**	**MSE**
Koala.jpg	22.30	24.08	2.00
Penguin.jpg	30.01	22.20	18.50
Apple.jpg	30.60	14.28	15.50

Table 2. Different Parameters of RLE Algorithm

Algorithm	Run Length Encoding		
Parameters	**CR**	**PSNR**	**MSE**
Koala.jpg	3.80	50.30	2.39
Penguin.jpg	1.19	30.40	1.52
Apple.jpg	1.30	36.20	0.50

Table 3. Different Parameters of DWT Algorithm

Algorithm	Discrete Wavelet Transform		
Parameters	**CR**	**PSNR**	**MSE**
Koala.jpg	12.20	45.80	0.30
Penguin.jpg	2.16	30.96	2.46
Apple.jpg	2.30	26.70	0.15

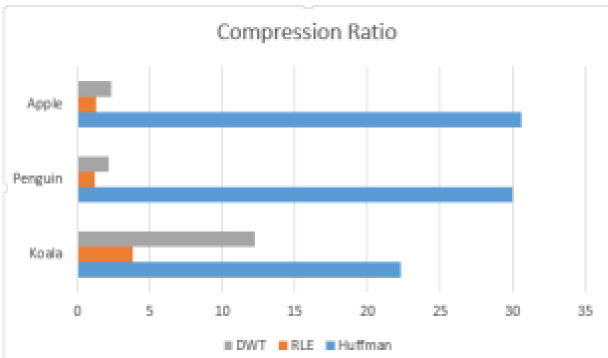

Fig. 11. Comparison Graph of Compression Ratios

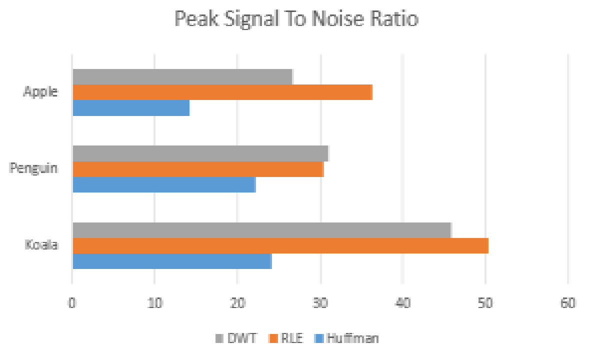

Fig. 12. Comparison Graph of PSNR

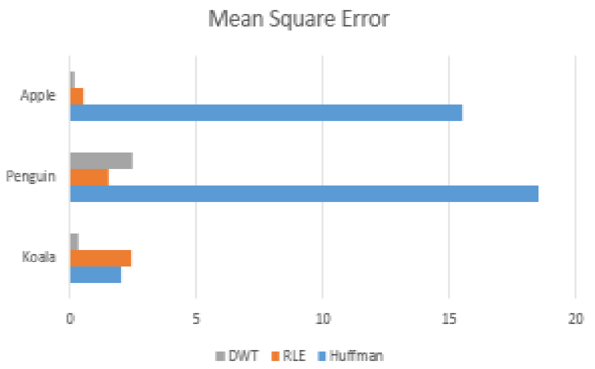

Fig 13. Comparison Graph of MSE

V. Conclusions

In this review paper we have implemented different image compression techniques on Matlab 2014a tool. The configuration of the system to run the matlab tool is 2 GB Ram and 512 GB Rom. We have calculated certain parameters i.e. Compression Ratio, PSNR and MSE by applying Huffman Coding, Run Length Encoding (RLE) and Discrete Wavelet Transform (DWT). Thus Huffman coding scheme has high compression ratio but RLE algorithm has a higher PSNR value.

Acknowledgment

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