

# IMAGE COMPRESSIONS TECHNIQUES: A REVIEW

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## Abstract:

Data compression refers to the process of reducing the amount of data required to represent a given quantity of information. With increasing need to store data in lesser memory several lossless compression techniques are developed. It describes the basic lossless and lossy techniques as Huffman encoding, run length encoding (RLE), arithmetic encoding, DWT, DCT, PCA, SPIHT and LM neural networks encoding briefly with their effectiveness under varying parameters. We review and discuss these algorithms for compressing grayscale images. Among all available techniques wavelet transforms have been found very useful.

**Keywords:** Lossless compression techniques, Huffman, Arithmetic, Run length Coding (RLE), DWT, DCT, SPIHT.

## I. INTRODUCTION

Multimedia images have become a vital and ubiquitous component of everyday life. The amount of information encoded in an image is quite large. Even with the advances in bandwidth and storage capabilities, if images were not compressed many applications would be too costly. Data compression is the technique to reduce the redundancies in data representation in order to decrease data storage requirements and hence communication costs. Reducing the storage requirement is equivalent to increasing the capacity of the storage medium and hence communication bandwidth. Thus the development of efficient compression techniques will continue to be a

design challenge for future communication systems and advanced multimedia applications. Data is represented as a combination of information and redundancy. Information is the portion of data that must be preserved permanently in its original form in order to correctly interpret the meaning or purpose of the data. Redundancy is that portion of data that can be removed when it is not needed or can be reinserted to interpret the data when needed. Most often, the redundancy is reinserted in order to generate the original data in its original form. A technique to reduce the redundancy of data is defined as data compression. The redundancy in data representation is reduced such a way that it can be subsequently reinserted to recover the original data, which is called decompression of the data.

## II. REVIEW OF LITERATURE

**Navjot Kaur, Preeti Singh (2012)**, In this paper a new method of image data compression for medical images has been proposed to achieve high PSNR (Peak Signal to Noise Ratio). Image compression using Set Partitioning In Hierarchical Trees (SPIHT) transform is being compared with the other well known wavelets like Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), Dual Tree Complex Wavelet Transform (DTCWT) and Embedded Zero-Tree Wavelet (EZW). The comparison is carried out in terms of coding efficiency, memory requirements, and image quality. This research paper presents an image compression

algorithm using Modified Fast Haar Wavelet Transformation (MFHWT) and SPIHT. It is considered that Haar functions are simplest wavelets [6]. **A. Mallaiiah, S. K. Shabbir, T. Subhashini (2012)**, here traditional image coding technology mainly uses the statistical redundancy between pixels to reach the goal of compressing. The research on wavelet transform image coding technology has made a rapid progress. Because of its high speed, low memory requirements and complete reversibility, digital wavelet transform (IWT) has been adopted by new image coding standard, JPEG 2000. The embedded zero tree wavelet (EZW) algorithms have obtained not bad effect in low bit-rate image compression. Set Partitioning in Hierarchical Trees (SPIHT) is an improved version of EZW and has become the general standard of EZW So, In this paper we are proposing DWT and SPIHT Algorithm with Huffman encoder for further compression and Retinex Algorithm to get enhanced quality improved image [1]. **D.VIJENDRA BABU, Dr. N. R.ALAMELU (2009)**, this paper presents an approach for an Enhanced Image Compression Method using Partial EZW Algorithm. This is based on the progressive image compression algorithm, EZW which is an extension of Shapiro's embedded Zero tree Wavelet Algorithm. The proposed Partial EZW Algorithm overcomes the difficulty of EZW that loses its efficiency in transmitting lower bit planes. In this paper, we include integer wavelet transformation and region of interest coding to Partial EZW and hence make it more superior to EZW and SPIHT Algorithm and it is proved with the results [4]. **S. Narasimhulu (2012)**, in this SPIHT is computationally very fast and among the best image compression algorithms known today. According to statistic analysis of the output binary stream of SPIHT encoding, propose a simple and effective method combined with Huffman encode for further compression. Here SPHIT algorithm are compared with the existing

methods for compression like discrete cosine transforms (DCT) and discrete wavelet transform (DWT). The lossy image compression algorithm is simple and effective method for grayscale image compression and is combined with Huffman encoding for further compression which in this paper that saves a lot of bits in the image data transmission [8]. **Sadashivappa (2011)**, here the files that comprise these images, are quite large and can quickly take up precious memory space on the computer's hard drive. In multimedia application, most of the images are in color. And color images contain lot of data redundancy and require a large amount of storage space. In this work, presented the performance of different wavelets using SPIHT algorithm for compressing color image. In this R, G and B component of color image are converted to YCbCr before wavelet transform is applied. Y is luminance component; Cb and Cr are chrominance components of the image. Image is compressed for different bits per pixel by changing level of wavelet decomposition. So we have tested the efficiency of color image compression using SPIHT algorithm. Huffman and arithmetic coding can be added to increase the compression. We can test the channel behavior by sending compressed image between two computers and check the reconstructed image [9]. **Sandeep Kaur (2013)**, in this Image compression is the application of Data compression on digital images. Thus the development of efficient compression techniques will continue to be a design challenge for future communication systems and advanced multimedia applications. This paper entailed the study of various image compression techniques and algorithms. Different techniques for digital image compression have been reviewed and presented that includes DFT, FFT, DCT and DWT. Wavelets, however has an advantage over older techniques that it doesn't have any blocking artifacts as in DCT. It is easy to implement and reduces

the computation time and resources required. Also, a new algorithm for image compression using Fast Wavelet Transform has been proposed as FWT reduces the problems of border distortions in Image Compression [10]. **Jyoti V. Kadam (2015)**, here author describes that to store digital image and video in raw form require large amount of memory space so, image compression means reducing the size of image file without degrading quality of image. Depending on the reconstructed image to be exactly same as the original or some unknown loss may incurred image compression divided into two techniques lossy and lossless techniques. Here presented hybrid model which is the combination of several compression techniques, Such as DWT, DCT and SPIHT implementation. Simulation has been carried out on different images like Lena, Barbra, Cameraman, Test drive. Result analysis is done through parameters like MSE, PSNR and Elapsed time. Values of parameters have gone better than the old algorithms because here SPIHT lossless technique and to hybrid combination of DWT and DCT get out good level of compression. The result analysis shows that the proposed hybrid algorithm performs much better in terms of PSNR with a higher compression ratio as compared to standalone DWT and DCT techniques [5]. **P. Tripathi (2012)**, defines the image compression is to reduce irrelevance image data in order to store the image in less memory space and to improve the transfer time of the image. Without compression, file size is significantly larger, usually several megabytes, but with compression it is possible to reduce file size to 10 percent from the original without noticeable loss in quality. There are so many compressions technique already presents a better technique which is faster and memory efficient. In this paper the Lossless method of Image Compression using Bipolar Coding Technique with LM algorithm in Artificial Neural Network is proposed by the author [7].

**Anjana & Mrs Shreeja (2012)**, describes the different methods used for compression. Recently used network is multilayer feed forward network due to its efficiency. The choice of suitable learning algorithm is application dependent. A new approach by modifying the training algorithm to improve the compression is proposed here. Protection of image contents is equally important as compression in order to maintain the privacy. If any malicious modification occurs either in storage or in transmission channel, such modifications should be identified. So authentication and protection are incorporated into the proposed system to enhance the security [2]. **Vikram Kumar (2014)**, Feed forward neural network based on the Levenberg-Marquardt Back-Propagation (LMBP) Algorithm by incorporating the effect of weather parameters, time factors and the previous day load information. The resulting data set is used for the training of a two layered neural network [11].

### III. COMPRESSION TECHNIQUES

Image compression is the process of reducing the amount of data required to represent a digital image. This is done by removing all redundant or unnecessary information. An uncompressed image requires an enormous amount of data to represent it. Image compression is thus essential for the efficient storage, retrieval and transmission of images. In general, there are two main categories of compression. **Lossless compression** involves the preservation of the image as is (with no information and thus no detail lost). **Lossy compression** on the other hand, allows less than perfect reproductions of the original image. The advantage being that, with a lossy algorithm, one can achieve higher levels of compression because less information is needed. Lossy/Lossless data compressions in Image Processing try to eliminate the spatial redundancies.

## A. PIXEL LEVEL CODING

**1. PCM (pulse code modulation):** The minimal number of bits per pixel possible to be achieved by PCM.

$\sigma_u^2 = R \frac{1}{2} \log_2 \frac{\sigma_u^2}{\sigma_q^2}$  the variance of the signal at the input of the quantizer;  $\sigma_q^2 =$  quantization error

**2. Entropy Coding:** The entropy  $H$  the source generating a data is in general impossible to measure in practice, due to the larger amount of inter dependencies (of infinite order) and the non-stationarities. Usually, a zero-order entropy measure is used to estimate the entropy of the source:

$$H_0 = -\sum p_i \log_2(p_i) \quad \text{icS}$$

It is impossible to compress data in a lossless way with a bit rate less than the entropy of the source that generated it.

**2. Huffman coding:** Probability model and symbol-to-codeword are combined. Input: sequence of symbols. Order the symbols according to their probabilities. Apply a contraction to the two symbols with the smaller probabilities. Repeat the previous step until the final set has only one member. Construction of a binary tree: The codeword for each symbol is obtained traversing the binary tree from its root to the leaf corresponding to the symbol.

$$l_{avg} = \sum l_i p_i$$

$$H(S) \leq l_{avg} \leq H(S) + 1$$

**3. Arithmetic coding:** A single codeword is used for an entire sequence of symbols. The code = a number in a sub-range of (0;1). A direct extension of Shannon-Fano-Elias coding calculate the probability mass function  $p(x^n)$  and the cumulative distribution function  $F(x^n)$  for the source sequence  $x^n$ . Arithmetic coding yields better compression because it encodes a message as a whole new symbol instead of separable symbols. Drawbacks of the arithmetic coding:

- limited by the representation precision for long sequences,

- an end-of-message flag is needed

**4. RLC (run length coding):** Run-length encoding (RLE) is a very simple form of data compression in which runs of data (that is, sequences in which the same data value occurs in many consecutive data elements) are stored as a single data value and count, rather than as the original run. This is most useful on data that contains many such runs: for example, simple graphic images such as icons, line drawings, and animations. It is not useful with files that don't have many runs as it could greatly increase the file size. For binary images, 0 – white, 1- black;  $p(\text{white}) \gg p(\text{black})$ ; encode the length of the white run, applications: fax; sketches

$$p(\text{white})=p(0)=p; p(\text{black})=p(1)=q; p \rightarrow 1.$$

**5. Substitutional (Dictionary based) coding:** The methods of the first group try to find if the character sequence currently being compressed has already occurred earlier in the input data and then, instead of repeating it, output only a pointer to the earlier occurrence. The algorithms of the second group create a dictionary of the phrases that occur in the input data. When they encounter a phrase already present in the dictionary, they just output the index number of the phrase in the dictionary.

**6. Bit-plane coding:** Process each bit plane individually. Bit-plane coding is based on decomposing a multilevel image into a series of binary images and compressing each binary image (e.g., using run-length coding).

## B. PREDICTIVE CODING

**1. DPCM coding:** To remove mutual redundancy between successive pixels and encode only the new information. There are two components to design in a DPCM system: a) the predictor: The predictor output, and

$$\hat{S}_0 = a_1 S_1 + a_2 S_2 + \dots + a_n S_n$$

b) The quantizer: A-law quantizer,  $\mu$ -law quantizer.

DPCM is only suitable for lossy image coding at high bit rate (small quantization noise).

**2. Delta modulation:** the simplest DPCM encoder; prediction from 1 sample, 1 bit quantizer.

$$\bar{u}^*(n) = u^*(n-1); \quad e(n) = u(n) - \bar{u}^*(n-1)$$

Alternatively, one can predict the value of the sample as:

$$\bar{u}^*(n) = \rho \cdot u^*(n-1) + \varepsilon(n);$$

$\varepsilon(n)$  = zero-mean error;

$\rho$  - factor which minimizes the mean square error (leak factor); given by the error covariance equation:

$$E[\varepsilon(n) \cdot \varepsilon(m)] = (1 - \rho^2) \sigma_u^2 \cdot \delta(m-n)$$

### C. TRANSFORM-BASED IMAGE COMPRESSION

An image block is transformed using a unitary transform, so that a large percent from the energy of the block is packed in a small number of transform coefficients. The transform coefficients are independently quantized. Transform the image into some other domain to reduce interpixel redundancy. The goal of the transformation process is to decorrelate the pixels of each sub-image, or to pack as much information as possible into the smallest number of transform coefficients.

**1. Karhunen-Loeve Transform or Principal Component analysis (PCA):** KLT is the optimum transform coder that is defined as the one that minimizes the mean square distortion of the reproduced data for a given number of total bits.

**2. Discrete Fourier Transform (DFT):**

$$g(x, y, u, v) = \frac{1}{N} e^{-j2\pi(ux+vy)/N}$$

$$h(x, y, u, v) = e^{j2\pi(ux+vy)/N}$$

**3. Walsh-Hadamard Transform (WHT):**

$$g(x, y, u, v) = h(x, y, u, v) = \frac{1}{N} (-1)^{\sum_{i=0}^{m-1} [b_i(x)p_i(u) + b_i(y)p_i(v)]} \quad (N = 2^m)$$

$b_k(z)$  is the  $k$ th bit (from right to left) in the binary representation of  $z$ .

**4. Discrete Cosine Transform (DCT):** The DCT can concentrate the energy of the transformed signal in low frequency, whereas the DFT cannot. For image compression, the DCT can reduce the blocking effect than the DFT. DCT works as a block based of 8X8 size. an image is first partitioned into non overlapped 8x8 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.

JPEG using DCT for handling interpixel redundancy. JPEG is a DCT-based image compression standard, which is a lossy coding method and may result in some loss of details and unrecoverable distortion.

$$F(u, v) = \frac{2}{N} C(u)C(v) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x, y) \cos\left[\frac{\pi(2x+1)u}{2N}\right] \cos\left[\frac{\pi(2y+1)v}{2N}\right]$$

for  $u = 0, \dots, N-1$  and  $v = 0, \dots, N-1$

$$\text{where } N = 8 \text{ and } C(k) = \begin{cases} 1/\sqrt{2} & \text{for } k = 0 \\ 1 & \text{otherwise} \end{cases}$$

$$f(x, y) = \frac{2}{N} \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} C(u)C(v) F(u, v) \cos\left[\frac{\pi(2x+1)u}{2N}\right] \cos\left[\frac{\pi(2y+1)v}{2N}\right]$$

for  $x = 0, \dots, N-1$  and  $y = 0, \dots, N-1$  where  $N = 8$

**5. Discrete Wavelet Transform (DWT):** DWT is a Subband Coding. The spectrum of the input data is decomposed into a set of band limited components, which is called subbands. Ideally, the subbands can be assembled back to reconstruct the original spectrum without any error. The input signal will be filtered into low pass and high pass components through analysis filters. To divide the spectrum of an image into the low pass and the high pass components. JPEG 2000 is a 2-dimension DWT based image compression standard.

**6. SPIHT:** It stands for Set Partitioning in Hierarchical Trees. SPIHT main Goal is as: **1.** Sort transform coefficients by msb- progressive selection of coefficients such that:

$$|C_{i,j}| \geq 2^n, n = n_0, n_0 - 1, n_0 - 2, \dots$$

2. Use Transform characteristics to identify efficiently groups with same msb.
3. Send remaining bits by order of importance – first those identifying msb– then those of same bit plane with larger msb's
4. Binary results of msb tests sent to decoder – enables decoder to duplicate encoder's execution path

In SPIHT two passes work Sort and refinement. The SPIHT encoding process utilizes three lists  
 LIP (List of Insignificant Pixels) – It contains individual coefficients that have magnitudes smaller than the thresholds

LIS (List of Insignificant Sets) – It contains set of wavelet coefficients that are defined by tree structures and are found to have magnitudes smaller than the threshold.

LSP (List of Significant Pixels) – It is a list of pixels found to have magnitudes larger than the threshold (significant).

The sorting pass is performed on the above three lists. The maximum number of bits required to represent the largest coefficient in the spatial orientation tree is obtained and represented by  $n_{max}$ , which is

$$n_{max} = \lceil \log_2(\max_{i,j}\{|c_{i,j}|\}) \rceil$$

During the sorting pass, those coordinates of the pixels which remain in the LIP are tested for significance by using equation

The result is sent to the output and out of it the significant will be transferred to the LSP as well as having their sign bit output. Sets in the LIS will get their significance tested too and if found significant, will be removed and partitioned into subsets. Subsets with only one coefficient and found to be significant, will be eliminated and divided into subsets. Subsets having only one coefficient and found to be significant will be inserted to the LSP; otherwise they will be inserted to the LIP. In the

refinement pass, the  $n$ th MSB of the coefficients in the LSP is the final output. The value of  $n$  is decremented and the sorting and refinement passes are applied again. These passes will keep on continuing until either the desired rate is reached or  $n=0$ , and all nodes in the LSP have all their bits output. The latter case will give an almost exact reconstruction since all the coefficients have been processed completely. The bit rate can be controlled exactly in the SPIHT algorithm as the output produced is in single bits and the algorithm can be finished at any time. The decoding process follows the encoding exactly and is almost symmetrical in terms of processing time.

**7. LM Neural Network:** Neural networks are suitable for linear as well as highly nonlinear functions with the adjustable biases and weights. The Levenberg-Marquardt (LM) algorithm can be used for nonlinear functions. LM is a combination of two methods, steepest descent and the Gauss-Newton method. Neural network based LMs outperform standard backoff n-gram models---Words are projected into low dimensional space; similar words are automatically clustered together; Smoothing is solved implicitly. Back propagation is used for training. The Levenberg- marquadt algorithm and two layer feed forward neural network was considered. A feed forward neural network is used to image coding consists of the following steps are: An image,  $I$ , is divided into blocks of pixels then scan each block in the form a input vector  $x$  ( $n$ ) of size:

$$P = \text{row} * \text{column};$$

It is assumed that the hidden layer of the layer network consists of  $L$  neurons each with  $P$  synapses, and it is characterized by an appropriately selected weight matrix  $Wh$ . All  $N$  blocks of the original image is passed through the hidden layer to obtain the hidden signals,  $h(n)$ , which represent encoded input image blocks,  $x(n)$ . If  $L < P$  such coding delivers image compression. It is assumed that the output layer consists of  $m = p = rxc$  neurons, each with  $L$

synapses. Let  $W_y$  be an appropriately selected output weight matrix. All  $N$  hidden vector  $h(n)$ , representing an encoded image  $H$ , are passed through the output layer to obtain the output signal,  $y(n)$ . The output signals are reassembled into  $p \times r \times c$  image blocks to obtain a reconstructed image,  $Fr$ . Training are conducted for a representative class of images using the Levenberg Marquardt algorithm. Once the weight matrices have been appropriately selected, any image can be quickly encoded using the  $W_h$  matrix, and then decoded (reconstructed) using the  $W_y$  matrix.

#### IV. Measuring Parameters

There are various criteria to measure the performance of a compression algorithm. However, the main concern has always been the space efficiency and time efficiency. Following are some measurements used to evaluate the performances of lossless algorithm.

i) **Compression Ratio:** It is the ratio between the size of the compressed file and the size of the source file.

$$\text{Compression ratio} = \frac{\text{Size after compression}}{\text{Size before compression}}$$

ii) **Compression factor:** It is the inverse of the compression ratio.

$$\text{Compression factor} = \frac{\text{Size before compression}}{\text{Size after compression}}$$

iii) **Saving percentage:** it calculates the shrinkage of the source file.

$$\text{Saving percentage} = \frac{\text{Size before compression} - \text{Size after compression}}{\text{Size before compression}} \times 100\%$$

#### V. CONCLUSION & FUTURE WORK

In a summary, the different Compression techniques are studied to Arithmetic coding techniques outperforms Huffman coding and Run Length Encoding. Also the Compression ratio of the Arithmetic coding algorithm is

better than the other two algorithms examined above. In this paper, it is found that the Arithmetic Coding is the most efficient algorithm among the selected ones of the digital images in any field, since it follows optimal method to remove redundancy from given data. Probabilities of symbol affect delay in processing. But those techniques which are dictionary based/inter-pixel redundancy based do not show any significant change in delay with change probability of symbol. the wavelet approach is superior to other approaches. SPIHT is a simple and efficient algorithm with many unique and desirable properties. The back propagation neural network and levenberg-marquardt algorithms estimating a connection counted that image compression and convergence time can be improved. This paper also contains image compression techniques using back propagation neural network with levenberg-marquardt algorithm. From all the above techniques LM back propagation is better in all aspect and DWT with SPIHT is also gives result better for compressing images as to get good outperform.

#### REFERENCES

- [1] A. Mallaiah, S. K. Shabbir, T. Subhashini, "An Spiht Algorithm With Huffman Encoder For Image Compression And Quality Improvement Using Retinex Algorithm", INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 1, ISSUE 5, JUNE 2012 ISSN 2277-8616.
- [2] Anjana, Mrs Shreeja "Image Compression: An Artificial Neural Network Approach" International Journal Of Computational Engineering Research Volume 2 Issue 8 , Page No 53-58 , December 2012.
- [3] Birendra Kumar Patel, Prof. Suyash Agrawal "Image Compression Techniques Using Artificial Neural Network" International Journal of Advanced Research in Computer Engineering & Technology Volume 2 Issue 10, Page No 2725-2729, October 2013.
- [4] D.VIJENDRA BABU, Dr. N. R. ALAMELU, "Wavelet Based Medical Image Compression Using

- ROI EZW”, Int. J. of Recent Trends in Engineering and Technology, Vol. 1, No. 3, Nov 2009.
- [5] Jyoti V. Kadam, Vijaykumar S. Kolkure, “DESIGN AND IMPLEMENTATION OF IMAGE COMPRESSION USING SET PARTITIONING IN HIERARCHICAL TREES AND HYBRID WAVELET TRANSFORM”, IJRET: International Journal of Research in Engineering and Technology, eISSN: 2319-1163 | pISSN: 2321-7308, Volume: 04 Issue: 02 | Feb-2015.
- [6] Navjot Kaur, Preeti Singh, “A New Method of Image Compression Using Improved SPIHT and MFHWT”, International Journal of Latest Research in Science and Technology, ISSN (Online): 2278-5299, Vol.1, Issue 2: Page No124-126, July-August (2012).
- [7] Prachi Tripathi “ Image Compression Enhancement using Bipolar Coding with LM Algorithm in Artificial Neural Network “International Journal of Scientific and Research Publications, Volume 2 Issue 8, August 2012.
- [8] S.Narasimhulu, Dr.T.Ramashri, “Gray-Scale Image Compression Using DWT-SPIHT Algorithm”, International Journal of Engineering Research and Applications, (IJERA) ISSN: 2248-9622 [www.ijera.com](http://www.ijera.com), Vol. 2, Issue 4, July-August 2012, pp.902-905.
- [9] Sadashivappa, K.V.S Anand Babu, Dr. Srinivas K “Color Image Compression using SPIHT Algorithm”, International Journal of Computer Applications (0975 – 8887), Volume 16– No.7, February 2011.
- [10] Sandeep Kaur, Gaganpreet kaur, “Comparative Analysis of Various Digital Image Compression Techniques Using Wavelets”, International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 4, April 2013, ISSN: 2277 128X.
- [11] Vikram Kumar, Akhil Gupta Dr. Sanjeev Aggarwal, “Artificial Neural Network Based Load Forecasting Using Levenberg-Marquardt Method”, International Journal of Advanced Research in Computer Science and Software Engineering, Volume 4, Issue 1, January 2014.