A DETAILED ANALYSIS OF THE DATA COMPRESSION TECHNIQUES IN IMAGE PROCESSING

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Abstract

An overview of computer technology in various fields has shortened the job of human beings but has also resulted in huge volume of digital data. Data compression helps us to reduce the given data size without missing the important information. The two types of compression are lossy and lossless compression. In this paper some of the lossy and lossless image compression techniques are discussed in detail. The rudimentary idea of image compression is to diminish the average number of bits per pixel necessary for their depiction. With the help of image compression, the storage space of images can be decreased and also the storage and transmission process is improved in order to save the channel bandwidth. As lossy technique is not reversible, recovering the real image using the lossless compression will be much useful. But in lossless technique the compression ratio is low when compared to lossy image compression technique. In this paper, it is discussed that the lossy techniques are better to compress the images which are given as an input in different image file formats.

Keywords- Compression Techniques, Cosine Transformation, Lossless Compression, Lossy Compression.

1. Introduction

Perception is defined as the process to receive and analyse the visual information by the researchers. When the same process is completed with the help of digital computer, it is called as digital image processing. Fig 1. shows the different stages of image processing scheme. Digital image processing [5] and analysis techniques are used today in a variety of problems. The thrust areas are Office Automation, Industrial Automation, Bio-medical, Remote Sensing, Scientific application, Criminology, Meteorology and Information Technology. Basic components of a general-purpose image processing system are digital computer, digitizer, sensor, operator console, mass storage and display. Four operations performed by this system are: image sensing, digitizing, processing and displaying. In general view of human's ancient enchantment with visual sensing, digital image processing is a recent development in the scientific field. It has been applied to practically every type of imagery. Pictorial displays are easy to interpret and carry huge information. The spatial distribution of image data are used for various transformations of images. The images can be compressed, filtered or the pattern of an image can be recognized.

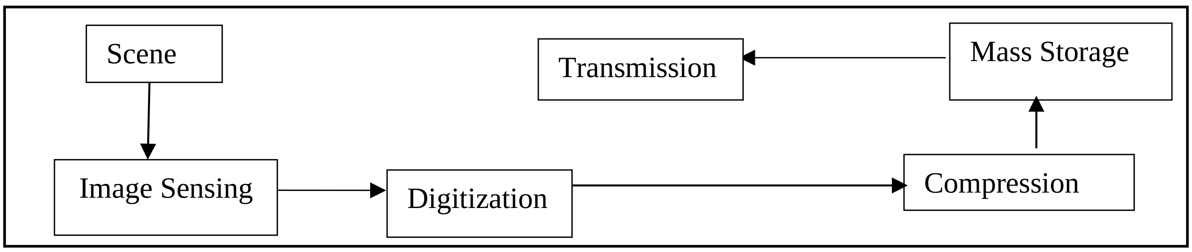

Fig 1. Different stages of image processing scheme.

Compression is the one which decreases resources required to store and transmit data. The process of studying the methods for minimizing the required bits to denote the input image is digital compression. Image compression minimizes the size of a graphics file without mortifying the quality of an image. The Discrete Cosine Transform (DCT) [30] has considered as the utmost widespread technique.

2. Image Compression Methods

There are various types of image compression techniques [26]. In general, the techniques are categorised into lossy and lossless compression. There are many types of compression methods in both lossy and lossless techniques [7]. The various lossless compression methods are Run Length Encoding, Huffman Encoding, LZW coding, Predictive coding, Arithmetic coding, Entropy coding and Area Coding. Some of the lossy compression methods are Transform coding, Spatial Domain Quantization, Fractal Based coding, Chroma Sub Sampling and Block Truncation. Transform coding can be achieved through DFT, DCT and DWT compression techniques. Figure 2 depicts various types of image compression techniques.

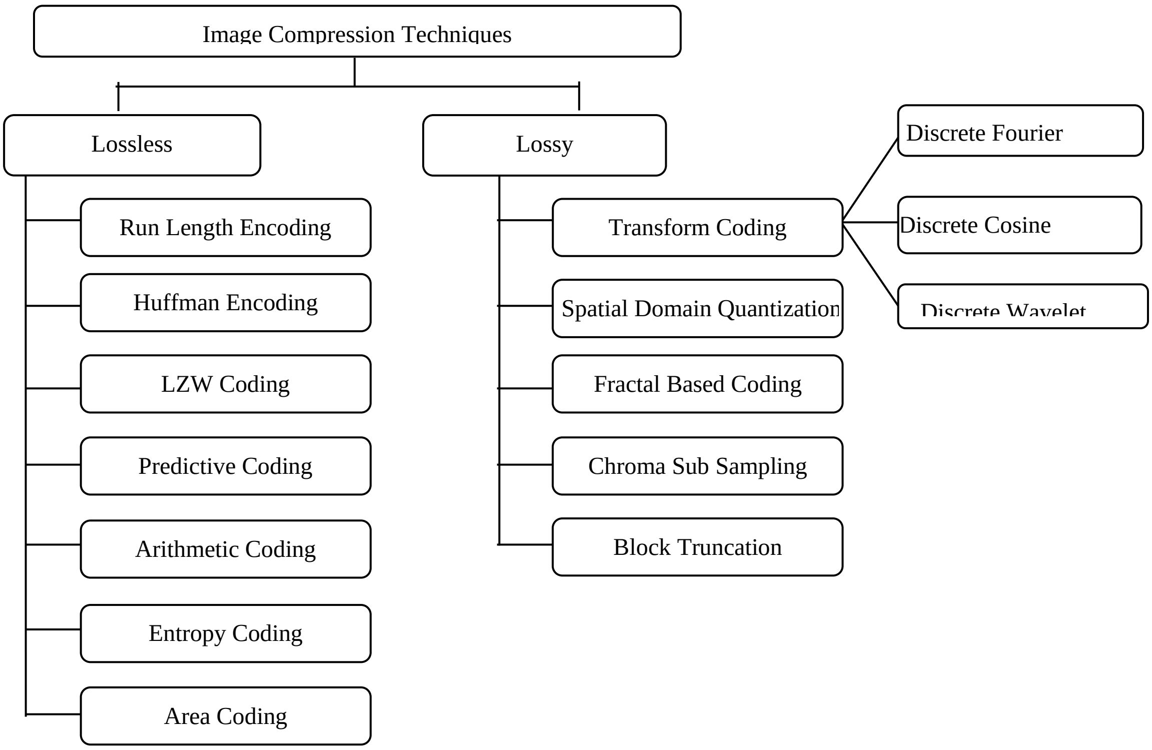

Fig.2 Classification of Image Compression Techniques

2.1 Lossless Compression Techniques

In lossless image compression it generates the compressed image without loss which is same as the original image [20]. Any part of the data will not be lost using this lossless algorithm. Compressing the executable programs is the main work done by lossless compression. Lossless algorithm saves the original data in least time even after compressing the data. [21].

2.1.1 Run Length Encoding

RLE is a compression in which data is replaced by a (length, value) pair, where value is the repeated value and length is the number of repetitions. The sequence in which the data value appears in many successive data elements and kept as a single value and count is called as run. This is very simple procedure useful in the case of redundant data. The steps of algorithm for RLE are as follows [1].

Step 1: Input the string.
Step 2: From first symbol or character give a unique value.
Step 3: Read the next character or symbol, if character is last in the string then exit otherwise.

2.1.2 Huffman encoding

Huffman coding (HC) is based on the rule of probability distribution [11]. This is one of the common method for coding symbols [1]. It is represented as statistical coding which efforts to reduce the quantity of bits used to signify a string of symbols [9]. The goal of the algorithm is to allow symbols to vary in length. Shorter codes are allocated to the most routinely used symbols, and lengthy codes to the symbols which perform less frequently in the string [28].

2.1.3 LZW coding

The compression algorithm created by Abraham Lempel, Jacob Ziv, and Terry Welch is the LZW [24]. LZW (Lempel - Ziv - Welch) is a dictionary based coding. It can either be static or dynamic. The dictionary is fixed during static coding and it is reorganised in dynamic coding [9] through the encoding and decoding processes. The public-domain program compression used the LZW coding [35]. The main impression is to create a table (a dictionary) of strings used for transmission session. The previously occurred strings can be replaced by their index in the table to reduce the quantity of information transmitted, when both the sender and the receiver have a copy of that table. The file formats such as GIF, TIFF and PDF [8] allows LZW.

2 1.4 Predictive Coding

The prediction of the value of each pixel by using the value of its neighbouring pixels is done by Lossless predictive coding, so that, all the pixels are encoded with an estimation error rather than its original value. The fewer bits are required to store the smaller errors when compared with the original value. For every equivalent element in the DPCM, the decoded and original image have similar value. The input image is splitted as blocks and the coefficients are estimated freely so that the estimated prediction for every block shows the variation in the lossless prediction coding is done by adaptive prediction [8].

2.1.5 Arithmetic Coding

The entire image sequence is assigned single arithmetic code word instead of coding each image pixel individually in Arithmetic Coding (AC). The interval 0 to 1 [0,1] is defined. The output is a single number < 1 and >= 0 in an arithmetic coding process. This single number can be distinctively decoded to create the meticulous stream of symbols that went into its construction. The symbols are defined as set probabilities to build the expected number [11]. The most powerful technique which involves much consideration in the recent work on lossless techniques is the AC. AC is considered as efficient and most flexible one. The intention of AC is to define a method that affords code words with an ideal length. The average code length is very near to the probable minimum given by information theory [23].

2.1.6 Entropy coding

The next lossless compression technique discussed is Entropy encoding. It works free regardless of the particular features of medium. Being used as a compression technique, it also measures the similarity in data streams. The working of the method is given as: An unique prefix-free code for every different symbol which is present in the input is created. Unlike RLE, the compression of data is done by changing the fixed length output with a prefix code word in entropy encoding. The result may be of different size after the prefix code is created. The negative log of probability will be the same as the result [6].

2.1.7 Area coding

The improved form of RLE is Area coding which helps us to identify the continuous '0's and '1's in the constant area coding. The image is divided into black or white pixels blocks with various intensity in Area coding [6]. In this method the input image is partitioned into block size that is m*n pixels which are classified into some blocks having only white pixels and some blocks having only black pixels or blocks with various intensity in this method [23].

2.2 Lossy Compression Techniques

In order to gain good compression rate, this compression lose some data. The exact original data cannot be retrieved back. This type of compression work on those data in which some reliability is acceptable. Possibly the lossy compression algorithm is used to compress picture, audio or video format because among these some loss of data can be accepted [1].

2.2.1 Transform Coding

This type of coding compress data like audio signals or images. It is an essential technique mentioned by JPEG. The spatial image pixel values are converted to transform coefficient values using transform coding [6]. By lowering its bandwidth, knowledge of the application is used to select information to remove in transform coding. Variety of methods are used to compress the remaining information. The important notion of transform based coding scheme hangs on ensuing coefficients for the input images which have small magnitudes. The different mathematical transforms such as DFT, WHT, and KLT, are well-thought-out for this particular task. The better transform coding and broadly used technique is DCT [23].

Discrete Fourier Transform

The Fourier transform is defined as a mathematical process with many uses in physics and engineering that states a mathematical function of time as the function of frequency, called S as its frequency spectrum [3]. The time domain signals are transformed into frequency domain signals using Fourier transforms. Time domain representation is the function of time that the frequency spectrum and the frequency domain representation works by transforming a function from a time domain to the task in the frequency domain.

Discrete Cosine Transform

The JPEG/DCT [2] compression is considered to be a standard in recent times. The image format designed for compressing natural images is the JPEG. The input image is divided as non-overlapped 8×8 blocks to exploit this method. After that it is converted into gray level pixels using DCT coefficients [18]. JPEG standard conducted by some visual evidence. To perform further compression by an efficient lossless coding strategy such as RLE, AC or HC, the quantized coefficients are rearranged in a zigzag scan order. Decoding is the exact contrary process of encoding and the time taken by the JPEG compression is same for both processes [29]. For testing real-world images, the encoding/decoding techniques are applied. The information loss occurs in the coefficient quantization process. The JPEG standard defines a standard 8×8 quantization table to every image which may not be applicable. The standard quantization table is applied previously but now it is replaced by adaptive quantization table because of its better decoding quality even with same compression applied to various input devices. [8].

Discrete Wavelet Transform

The most advantageous and useful computational tool for a multiplicity of signal and image processing applications is the wavelet transform [14]. It is mainly used in images for removal of unnecessary noise and blurring. For both data and image compression, wavelet transform has come to light as the most powerful tool. It performs multiresolution image analysis. The image processing applications including clearing of noise, detecting the edges and compression applies DWT successfully [22]. Wavelets are functions outlined over a limited interval and having an average value of zero. Signifying the arbitrary function (t) as a superposition of a set of such wavelets is the main procedure of wavelet transform [34]. The transforms related to image compression has in recent times received an increasing interest. Victimizing the idea of multiresolution signal decomposition with the wavelet illustration and also the conception of Embedded Zero tree Wavelet (EZW) [16] based on the decaying spectrum hypothesis, the current progressive wavelet approach appeals a wavelet remake on pictures in a pyramid fashion up to the expected scale. Figure 3 shows the discrete wavelet transform model.

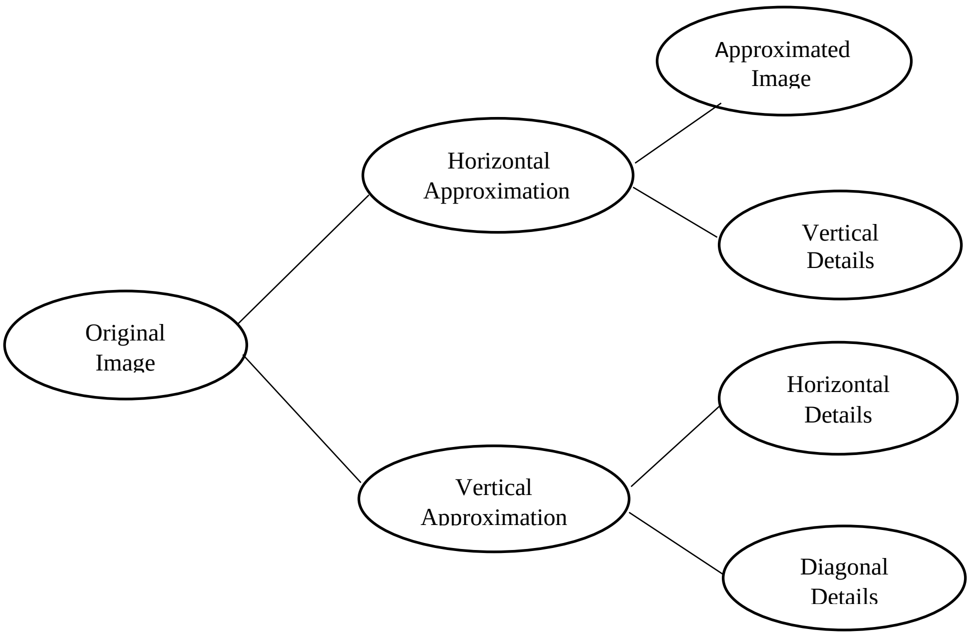

Fig.3 Discrete Wavelet Transform Model

2.2.2 Spatial Domain Quantization

Scalar Quantization

Scalar quantization is the most common type of quantization. Scalar quantization means applying quantization function Q to map a scalar input value p to a scalar output value R. It is denoted as R=Q (p). Scalar quantization is considered to be easy and instinctive as it rounds high precision numbers to the nearest integer, or to the nearest multiple of some other unit of precision [13].

Vector Quantization

The important method to develop a dictionary of Fixed- size vectors called code vectors is the Vector Quantization [17]. The input image is partitioned as non-overlapping blocks and then for each value dictionary is determined. Then the index generated for the dictionary is used as the encoding for that original image [1]. The large set of points are divided and grouped to have about the same number of points closest to them. The density matching property of vector quantization is used to identify the density of high-dimensional data. Commonly occurring data have low error and rare data high error because the data points are pointed by the index of their closest centroid. This is the reason to suit vector quantization to lossy data compression. VQ is also used for lossy data correction and density estimation [13].

2.2.3 Fractal Based coding

One of the lossy compression method for digital images, based on fractals is the Fractal Image compression [31]. The main aim of this algorithm is to partition the input image into segments by applying standard image processing techniques such as color partition, edging, and spectrum and quality analysis [22]. This particular method is mainly suited for textures and natural images, i.e. fact that some parts of an image often have redundant copies in other parts of the same image. Fractal algorithms convert that parts into "fractal codes". The fractal codes are applied to reconstruct the encoded image [35].

2.2.4 Chroma subsampling

The power of the human eye's lower vision for color variations is present in this method. This is due to the averaging or dropping of the intense information in the image. Video encoding is one of the application of this technique. The method that holds color information at lower resolution than intensity information is the Chroma Subsampling [1].

2.2.5 Block truncation coding

BTC is considered to be the best compression technique for gray scale images. This method works with digitized gray scale images. This achieves 2.0 bits per pixel (bpp) with low computational complexity [27]. Here, the image is partitioned and a block of pixels are arranged and a threshold and reconstruction values are found for each block. Then a bitmap of the block is derived and all those pixels got replaced which have the value greater than or equal to the threshold value by 1or 0 [1]. In order to improve the BTC technique, the encoding is divided into three tasks: accomplishing the quantization of a block, coding the quantization data, and then coding the bit plane. The image is divided into non-overlapping blocks of pixels. Determine the threshold and reconstruct the value for each block. The threshold is regularly the mean of the pixel values in the block. All the pixels are replaced and the value is reconstructed. This results in the average of the values of the matching pixels in the original block [23].

3. Discussions

The various image compression techniques of lossy algorithms are listed and discussed in the table 1.

Table 1 Comparative study of the Existing Transform Coding Methods

S.No	Image Compression Techniques	Author and Year	Applications / Advantages	Parameters Used
1	Run Length Encoding	Diya Chudasama, Khushboo Parmar, et al, IJERT, 2015	Used often for repeatedly arising sequences of pixels	Compression Ratio (CR)
2	Huffman Encoding	Vikash Kumar, Sanjay Sharma, IJSCE, 2017	Less time for compression and decompression	CR, PSNR

3	LZW Coding	Fengyuan Zhanga, Zhao Li, et al, Elseveir, 2011	Lessens the compression time	Compression Efficiency, Compression Time
4	Predictive Coding	Rupali Sachin Vairagade, Rekha Kulkarni, IJCET, 2014	Good quality image with less data loss, Low bandwidth	CR, MSE PSNR,
5	Arithmetic Coding	P.Suresh Babu, S.Santhiya, IJARBEST, 2016	Better performance and good quality of image	BPP, CR
6	Entropy Coding	D.Malarvizhi, Dr.K.Kuppusamy, IETT, 2012	Reduce the number of bits required to represent an image	PSNR, MSE
7	Area Coding	Pratishtha Gupta, G.N.Purohit, Varsha Bansal, IJARCCE, 2014	Reflects 2-D character of images	CR
8	Scalar Quantization	Gaurav Vijayvargiya, et al, IJCSIS, 2013	Simple and Intuitive	CR, Signal to Noise Ratio, Speed of encoding and decoding
9	Vector Quantization	Gaurav Vijayvargiya, et al, IJCSIS, 2013	Powerful density matching property	CR, Signal to Noise Ratio, Speed of encoding and decoding
10	Fractal Based Coding	Amit Kumar Biswas, Sanjeev Karmakar,et al, IJAIS, 2015	Enhance the reconstructed quality of compressed medical images with high compression ratio	CR, PSNR, Encoding time (s)
11	Chroma Sub Sampling	Pavel Pokorny, WSEAS Transactions On Computers, 2016	Reduce the amount of image data	CR
12	Block Truncation	Dev Prakash Singh, Dr. Vineeta Saxena Nigam, IJIRCCE, 2017	Good quality image with high bit-rate	PSNR, MSE
13	DWT	Salam Benchikh and Michael Corinthios, IEEE, 2011	Symmetric, unitary and reversible	Image test, Wavelet function, number of iterations and calculation complexity
		M. MozammelHoque Chowdhury and Amina Khatun,IJCSI,2012	Better image quality, better performance and high compression ratio	CR, PSNR (Peak Signal to Noise Ratio)
		R.Praisline Jasmi, Mr.B.Perumal, Dr.M.PallikondaRajasekaran, IEEE, 2015	Noise reduction, edge detection and compression	MSE (Mean Square Error), PSNR, BPP (Bits Per Pixel)
		Allaeldien Mohamed G. Hnesh, HasanDemirel, IEEE, 2016	Discretely sampled wavelets	Haar function
		MouradRahali, HabibaLoukil, Mohamed SalimBouhlel, IEEE, 2016	Better transformation, Improved compression	CR, PSNR

14	DCT	Aree Ali Mohammed, Jamal Ali Hussein, IEEE, 2011	Tested against different medical images proving that compressed medical images preserve its quality where quantization factor is less than 0.5.	Quantization factor, CR, PSNR
		Padmavati.S, Dr.VaibharMesharam, IEEE, 2015	Reduces the entropy of all images, Provides optimal decorrelation, Improvement in computation efficiency	PSNR, CR, Encoding Time, Decoding Time
		Sharmin Afrose, SabrinJahan, Anuva Chowdhury, IEEE, 2015	Excellent de-correlation property, decrease in entropy of the image	CR, MSE, PSNR
		Shubh Lakshmi Agrwal, DeekshaKumari, sMeeta Sharma, Sandeep Kumar Gupta, IEEE, 2016	Matrix converted to frequency domain, data reduction It is performed on wbarb and bust images	Objective and Subjective evaluations to evaluate the quality of image compression, PSNR
15	DFT	Mridul Kumar Mathur, GunjanMathur, IJETTCS,2012	Provides lossy compression of images both in grayscale and color	CR, MSE, PSNR
		S.S. Pandey, Manu Pratap Singh, Vikas Pandey, IJCET, 2015	Better quality of gray scale images	PSNR, CR
		M. A. M. Y. Alsayyh, D. Mohamad, T. Saba, A. Rehman, J. S. AlGhamdi, JIHMS, 2017	Low bit rate, Good compression quality	CR, MSE, PSNR

From the Table 1, it is found that the transformation techniques are better than the other image compression techniques like Run length encoding, Area coding, Huffman encoding, etc.

4. Conclusion

In this paper, a comparative study of the compression methods is provided on recent lossy and lossless image compression algorithms. The three existing transform coding techniques namely DCT, DWT, DFT are premeditated and conferred. Many algorithms are developed by performing some variation on basic ideas of these techniques to provide better performance. Based on different technologies, it is concluded that most of the algorithms use PSNR value, Mean Square Error and Compression Ratio as a quality measure for image compression.

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