Review Article CODEN: IJPAKY Impact Factor: 4.226 ISSN: 2319-507X
Pavithra DR, IJPRET, 2017; Volume 6 (5): 26-38 IJPRET

INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

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A REVIEW ON VARIOUS IMAGE REPRESENTATION TECHNIQUES AND OUTCOMES

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Accepted Date: 16/12/2017; Published Date: 01/01/2018

Abstract: - Image compression is a vital application and serious issue in an image processing task, which minimizes the size in bytes of a digital image file. In an Image Processing (IP) applications, several researchers have presented various image compression techniques. In this paper, an effort has been made to highlight the various research works carried out and comparative performance parameters of those works in image compression techniques. An attempt has also been made to present various approaches of image compression techniques. Also, this paper highlights the essentials of compression, principles, constraints, and image compression classes.

Keywords: Image Compression, Lossy Compression, Lossless Compression

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Access Online On:

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How to Cite This Article:

Pavithra DR, IJPRET, 2017; Volume 6 (5): 26-38

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INTRODUCTION

As name infers, compression deals with methods for decreasing the memory necessary to store an image, or the bandwidth needed to communicate it. Though storage technology has enhanced considerably over the earlier era or decade, the similar cannot be said for communication capability [1]. It is factual specifically in uses of the Internet that are considered by major pictographic content. Image compression is aware to maximum users of computers in the type of image file extensions, i.e, the jpg file extension used in the JPEG image compression standard.

Image compression is a vital applications in an image processing task, used for transferring and saving a digital image / image file in data bases. The saving of digital image / image file without compression would be a tragedy. Hence, reduction in file size permits huge amount of images to be stored in an available memory. Also lessens the time needed for images to be sent via Internet or downloaded from various web pages.

Image compression contains the usage of fractals and wavelets techniques which offer better compression ratios than the JPEG / GIF techniques for certain kinds of images. Hence, compression of the Image is one of the useful and important applications of the wavelet transform and successfully used for encoding of the lossy images. Wavelets are familiar analytical tool with noble features and a many applications. The wavelet transform annihilate polynomials, as a result obtaining in a condensed representation of the examined signal. Therefore, it is desired for compression, denoising and various applications that depending on sparse interpretation or extraction of features.

1. PROCESS OF IMAGE COMPRESSION

The various blocks of General Image Compression System is illustrated in Figure 1. The key objective of the system is to decrease the storage size of an input image as less as possible and to decode image comparable to the original image.

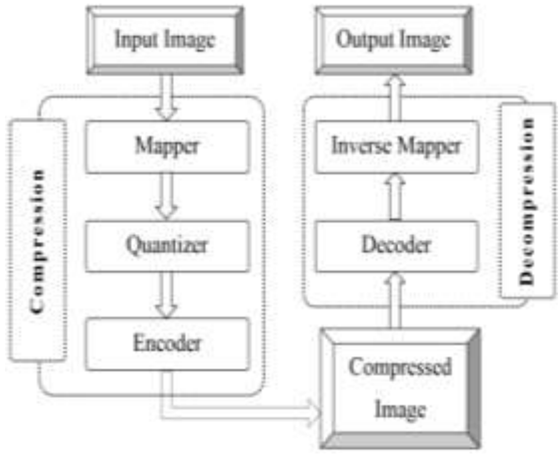

Figure 1.Process of Image Compression and Decompression

In Compression process of Figure 1, initially an input image is passed through the mapper which transforms the input image into a format aimed to lessen interpixel redundancies. In general, the mapper is reversible and the volume of data necessary to represent the image may / may not decrease directly. The mapper's output accuracy is decreased by the quantizer according to some pre-established reliability decisive factor. The psychovisual redundancies of the input image is decreased. The operation of the quantizer is irreversible and not necessary in lossless compression. Encoder constructs a fixed / variable - length code to denote the output of the quantizer and output is mapped according to the code and it is reversible.

2. FACTORS TO BE CONSIDERED IN IMAGE COMPRESSION

Various factors to be considered for evaluating the performance of an image compression technique are as follows.

2.1. Compression Efficiency

The efficiency of compression is determined by Compression Ratio (CR). Compression Ratio is calculated as

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

Therefore the memory space saved is given by

$$MS = 1 - \frac{Size\ of\ Compressed\ Image}{Size\ of\ Original\ Image}$$

Where, MS = Memory Savings

2.2. Quality of an Image

After an image is compressed, an input image keeps its originality in its quality without any loss in its content, hence called as lossless image compression. An image quality can be measured by two significant factor such as Peak Signal to Noise Ratio (PSNR) and Mean Square Error(MSE). PSNR is a peak error measurement between compressed & original image and if the original image is $I_1[m,n]$ and the compressed image is $I_2[m,n]$ then the Mean Square Error (MSE), is given by

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

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

R = Relative Data Redundancy with *b* bits, R=1-1/C, where C is compression ratio.

2.3. Cost of Computation

A major factor to be considered is cost of computation in image compression. The computation cost of an image compression should be as low as possible.

2.4. Encoding and Decoding Time

In an image compression process, as the number of computations increases, the time of computation also increases resulting in overall compression time. Reducing computational time enhances the speed of compression.

3. IMAGE COMPRESSION APPROACHES

The Figure 2 depicts the various approaches of Image Compression technique

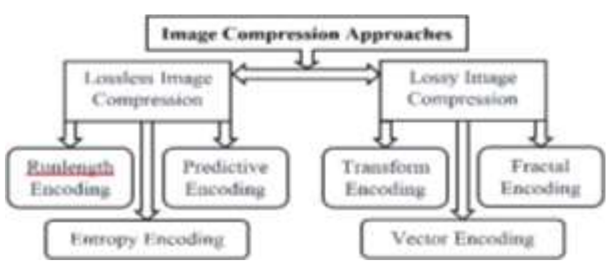

Figure 2. Image Compression approaches

4.1. Lossless Compression Approaches:

In an image compression process, a compressed image is numerically equal to an original image known as Lossless Compression technique thought can achieve only a moderate amount of compression comparing to lossy compression. In this compression, all the data bits of an image file retains after the file is uncompressed. Original image information is fully regained. This technique generally used where losing of information is not acceptable.

4.1.1 Run-length Encoding (RLE)

It is a very wide spread, clear-cut and easiest lossless data compression technique. Here, the count of rate of same data is stored as a single data value and single count. RLE is functional for the images which comprises several such runs, enormous amount of similar data value: for example, a simple RGB as similar color arise several times. It is less useful with RGB images that do not have many runs or same value data as it could to a great extent increase the size of files. The Run length encoding technique performs a lossless compression of input images that is depending upon the sequences of the same values (runs). Using RLE, there is no degradation in the quality of an image as it breaks the big run sequences into small run sequences.

Edward L Huack invented a patented compression device [2] uses a Run-length encoding scheme which has a flag byte symbol which is placed between a run length symbol and character signal along with statistical encoding.

4.1.2 Predictive Encoding (PE)

It is an effective lossless image compression. The prediction of each pixel value is determined by neighboring pixel value. The value of each pixel is encoded by its prediction error which are smaller so that lesser bits are necessary to store them. The lossless predictive coding variation is an adaptive prediction, which divides an image into modules and calculates the prediction factors independently for all the module to obtain better prediction performance. A new and simple predictive coding technique is proposed [3], which approximates the value of the color pixel based on the quantized pixel colors of three neighboring pixels.

4.1.3 Entropy Encoding

An objective of the Entropy encoding is to decrease the number of bits required to code the image without information loss. The most probable symbols are corresponds to shortest codewords and the least probable symbols corresponds to largest codewords. Following are the widely used entropy encoding methods.

4.1.3.1 Huffman Coding

This coding method is depending on the rate of recurrence of pixel in images. The most frequently occurring pixel values are coded with the lower number of bits. For each image (or set of images), a codebook is created to store the codes. The encoded data along with the code book is communicated to the decoder for decoding. As this method is very simple and high speed, it is widely used as 'back-end' too for few other compression techniques. Huffman is less efficient than RLE and is relatively slow process. An image compression technique using Huffman Coding is presented in [4].

4.1.3.2 Arithmetic Encoding

It is known as Non-block code, where there is no one-to-one correspondence with respect to source symbols and code words. Here, an arithmetic code word between 0 and 1 is assigned to the whole sequence of source symbols. 1-bit image compression is impossible in Huffman coding as it uses integer number of bits for all the symbols so that arithmetic encoding is used as solution to overawed the restraint of Huffman coding. Arithmetic coding can be perceived as a generalization of Huffman coding as it is at ease to discover an arithmetic code for a binary input than for a non-binary input. In [5], a new lossless image compression approaches using arithmetic coding is represented for high resolution images and gained superior compression ratio.

4.1.3.3 LZW coding

The major aim of LZW is allocating code words of fixed-length to variable length code of source symbols to obtain the better compression i.e., strings of characters are replaced by single codes. LZW adds each and every new characters string to the table of strings instead of analyzing the incoming text. String of characters are replaced by single code output for compression. This output may be of any length, but must have more bits than single character. The files having huge repetitive text data and monochrome image can be better compressed by LZW coding. This coding technique is fast and used in a TIFF, GIF and PDF file formats. A more effective, data-hiding LZW method is given [6], which reversibly conceals data in LZW compression codes by reducing the length of the symbol.

4.2 Lossy Compression Approaches

In an image compression process, a compressed image is dissimilar to an original image known as Lossy Compression technique. In this technique, there will be some amount of irreversible loss in data of an original image but it offers a digital image recording system that is currently broadly accepted in medical field to obtain better compression. In text compression, information loss is usually unacceptable, though simple schemes like deleting all vowel from text is somewhere useful. The loss of information for images and sound is also acceptable, even imperceptible. In usual observing situations, invisible loss (visually lossless) is present.

4.2.1 Transform Encoding

The major necessity of transformation is to transform the data to make compression easier. This transforms the correlated pixels into a decorrelated representation. The newly obtained values are normally lesser on average than original values. The purpose of transformation is to lessen the redundancy of depiction. In order to produce more compressed representation of an input image data, the coefficients of transformation are quantized based on their statistical properties. Following are the some of the important Transform Coding Methods:

4.2.1.1 Hermite Transform (HT)

This transform is a distinctive case of polynomial transform model for representation of an image, which is used to solve the fusion problem in multimodal medical imagery. This contains few significant properties of visual perception of a human, i.e., early vision guassian derivative model and local orientation analysis. A local function x(x, y) windowing occurs at various positions on an original image and in view of a orthogonal polynomials family, local information at each analysis window is prolonged. The polynomials Gm, n_m(x,y) used to estimate the windowed data are verified by the window function of analysis and fulfill the orthogonal condition

$$\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} \omega^2(x,y) G_{m,n-m}(x,y) G_{l,k-l}(x,y)\,dx\,dy = \delta_{nk}\delta_{ml}$$

for n, k = 0 to ∞, m = 0 to n and l = 0 to k; where dnk signifies the Kronecker function.

An efficient Hermite transform model is presented for local image analysis and medical image fusion application in [7].

4.2.1.2 Discrete Cosine Transform (DCT)

The DCT describes an image as no. of changeable signal amplitudes and also the frequencies. The 2-dimensional DCT of an image is achieved by Discrete Cosine (DC-2) function. The DCT has sole feature, that is, for a precise image, utmost of the visual info in an image is concerted only in a few no. of co-efficients of the DCT. Here, the mainstream of the signal info intense in only some of the low-frequency components.

4.2.1.3 Karhunen Loeve Transform (KLT)

Using algorithms such as JPEG the transformation is known before but Karhunen-Loeve image compression is a transformation based method for compressing images, in which a special matrix is used based on the image data. Greater compression can be accomplished by the property of de-correlating the covariance matrix of data. Predetermination of auto-covariance matrix of the data set, its diagnalization and construction of the basis vector which cannot be calculated earlier and completely repeated when any new data is given based on the signal are all necessary to implement the KLT. Even though the more computational complexity has made KLT a best but impractical tool, it does provide a benchmark against which other discrete transform may be judged.

Examination on the rate-distortion performance penal-ties and complexity tradeoffs associated with using the KLT and its fast approximations in transform coding is presented in [8].

4.2.1.4 Wavelet Transform (WT)

Wavelets with different locations and scales gives the representation of an image known as Wavelet Transform.

Using Wavelets de-composition of an image implicates 2 waveforms one to describe the high frequencies corresponding to the details parts of an image and one for the low-slung frequencies or smooth parts of an image. Wavelet functions are generated at diverse locations and dissimilar scales by the 2 waveforms transformed and scaled on the time axis. Low frequencies are scaled with high scale function and high frequencies are scaled with low scale functions. Wavelet coefficients given by wavelet transform determines the role of the wavelets at these positions and ranges. One of the lossy compression techniques is DWT (Discrete Wavelet Transform). In [9] DWT provides enough compression ratios with no significant reduction in the quality of an image. This Compression method offers improved performance with the other conventional methods. Wavelets are added suitable for time limited facts and this method conserves improved image quality by decreasing the errors.

4.2.2 Fractal Encoding

Fractal encoding is one of the lossy compression techniques in an image of digital form, depending on fractals. This technique is one of the superlative methods to compress the texture and also native images, based on the truth that the parts of an image repeatedly be similar to remaining components of the original image. This types of algorithms translates these components to numerical data termed as "fractal codes" that are used for recreating an encoded image. In [10] Fractal image compression is achieved by separating the original grey-level image to un overlapped parts based on a threshold value and a distinguished method of Quad- tree de-composition and Huffman coding for image encoding and decoding.

4.2.3 Vector Encoding

Vector quantization is an efficient technique for lossy compression of the images, as their vector space representations takes simply little fractions of their vector spaces. An idea of Vector encoding to an image compression depends on restoring distinguishable image blocks (vector Spaces) by a number of model blocks which are the majority representative blocks of original image. Because of the human being perception of the eyes are depends on considering bigger image components, changes done by the vector quantization technique cannot be noticed at all.

Vector quantization (VQ) is the efficient technique to lessen the full amount of information necessary to represent an image as it compresses in vectors more efficiently than using scalars [11, 12].

4. RELATED WORK

Various research works are carried out and also going on by several researchers on Image compression. Here, compression is achieved using Adaptive Wavelet Filter banks based on Lifting Scheme. A few related works pertaining to research since year 2010 are carried out are highlighted in the below table.

Table 1. Performance parameters achieved by various algorithms by researchers in last 5 years

Algorithm / Method used	Perform-ance Paramet-ers	Result / Remarks
Adaptive 2-D FB based on the Lifting scheme with desirable dual and primal vanishing moments and quincunx sampling with adaptation	PSNR	Higher computational time

method called ICI rule [13]		
Adaptive Wavelet FB using LAD criterion for fixed size sliding window [14]	Computational Time for described image decomposit-ion methods	Increased numerical complexity
Recursive Least Square error criterion. [15]	Tuning of the filter properties	Proper choice of adaptation algorithm is still a problem
Lifting based wavelet using SPIHT method [16]	Compression Ratio, MSE, PSNR, Encoding and Decoding time	BPP is High.
Adaptive Directional Lifting Based 9/7 wavelet Transform with SPIHT [17]	Improved PSNR, Reduces edge artifacts and ringing	Not effective for images whose energy is concentrated on the high frequency region
Comparison of Classical and Lifting based Wavelets [18]	Compression Ratio, MSE and PSNR	Classical wavelets produces less PSNR and Compression ratio.
Optimizing technique of lowpass and highpass synthesis delay filter coefficients. (Bi-orthogonal Daubechies 9/7 filters) [19]	PSNR and MSE	Improved PSNR for lower bit rates
Improved wavelet based compression with adaptive lifting scheme using Artificial Bee Colony(ABC) algorithm [20]	Compression Ratio, PSNR, Encoding and decoding time	To find the optimum threshold value using ABC algorithm
Learning Adaptive Filter Banks for Hierarchical Image Representation using de-convolutional network [21]	PSNR for different coefficient ratio	Optimization problem should overcome with efficient algorithms
Adaptive Wavelet FB using LAD criterion with 2 vanishing moments	MSE, MAD, MAE and SNR in dB	Non-existence of the closed form LAD solution

and one adaptive parameters[22]

5. CONCLUSION

In this paper, various compression techniques are discussed considering both lossless and lossy approaches and also the comparison of existing algorithms and their performance for image representation. In Lossy approaches using wavelet transforms, lifting scheme take advantage of a spatial domain, prediction error analysis of the wavelet transform & presents an effective structure for designing transform for the purposes of the signal de-noising. Benefits of Wavelet filter banks which map integer to integer are applied for lossless image compression. Compression of natural and smooth images are better done with the filter banks having high analyzing vanishing moments rather than images with edge and high frequency components. Performance of the filter banks which adjust to the signal variations by changing the number of zero moments are better than fixed filter banks and is very useful in compact representation of an image. The Precise adaptation can be smeared depending on the Least Absolute Deviation (LAD) principle than Least Mean Square (LMS) adaptation. The Set Partitioning in Hierarchical Trees (SPIHT) algorithm is used by using considering the lifting scheme for compression of the images. An Improvement in PSNR for low bit rates can be accomplished by using Adaptive synthesis filters banks.

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