Technologies for Digital Image Compression –A Review

Malvika Dixit[1] Harbinder Singh[2]
[1]M.Tech Student [2]Assistant Professor
[1,2]Department of Electronics & Communication Engineering
[1,2]Baddi University of Emerging Sciences & Technology

Abstract— Compression is one of the most important applications of wavelets. The compression procedure contains three steps. First is Decompose in which Choose a wavelet, choose a level N. Compute the wavelet decomposition of the signal at level N. Second is Threshold detail coefficients where For each level from 1 to N, a threshold is selected and hard thresholding is applied to the detail coefficients. The third one is Reconstruct which Compute wavelet reconstruction using the original approximation coefficients of level N and the modified detail coefficients of levels from 1 to N. Second approach Vector quantization (VQ) is a lossy data compression method based on the principle of block coding. It is a fixed-to-fixed length algorithm. In the earlier days, the design of a vector quantizer (VQ) was considered to be a challenging problem due to the need for multi-dimensional integration. In 1980, Linde, Buzo, and Gray (LBG) proposed a VQ design algorithm based on a training sequence. The use of a training sequence bypasses the need for multi-dimensional integration. A VQ that is designed using this algorithm are referred to in the literature as an LBG-VQ. This paper presents a review of existing digital image compression techniques.

Key words: MCSA, Vector quantization, Biorthogonal wavelet

I. INTRODUCTION

An image may be defined as a two-dimensional function, *f*(x, y), where x and y are spatial (plane) coordinates, and the amplitude of *f* at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point. When x, y and the amplitude values of *f* a real finite, discrete quantities, we call the image a **'**digital image**'.** Image compression is used to minimize the amount of memory needed to represent an image. Images often require a large number of bits to represent them, and if the image needs to be transmitted or stored, it is impractical to do so without somehow reducing the number of bits. The problem of transmitting or storing an image affects all of us daily. TV and fax machines are both examples of image transmission, and digital video players and web pictures of Catherine Zeta-Jones are examples of image storage. In recent year, many numbers of applications need large number of images for solving our problem. Digital image can be store on disk and this storing space of image is also important because less memory space means less time of required to processing for image. The concept of image compression "Image compression means reduced the amount of data required to represent a digital image". A method and system for transmitting a digital image (i.e., an array of pixels) from a digital data source to a digital data receiver. More the size of the data be smaller, it provides better transmission speed and saves time. There are many applications where the image compression is effectively increased efficiency and performance like Health Industries, retail stores, federal Government Agencies, security industries, museums and galleries etc.

Digital image can be store on disk and this storing space of image is also important because less memory space means less time of required to processing for image. The concept of image compression "Image compression means reduced the amount of data required to represent a digital image". A method and system for transmitting a digital image (i.e., an array of pixels) from a digital data source to a digital data receiver. More the size of the data be smaller, it provides better transmission speed and saves time. There are many applications where the image compression is effectively increased efficiency and performance like Health Industries, retail stores, federal Government Agencies, security industries, museums and galleries etc.

II. IMAGE COMPRESSION

Image compression is the process of reducing the amount of data required to represent an image. How to achieve compression means by removing the redundant information, we can achieve it. Even though disks are getting bigger and high bandwidth is becoming common, it's nice to get even more value by working with smaller, compressed files. For large data warehouses, like those kept by Google and Facebook, halving the amount of space taken can represent a massive reduction in the space.

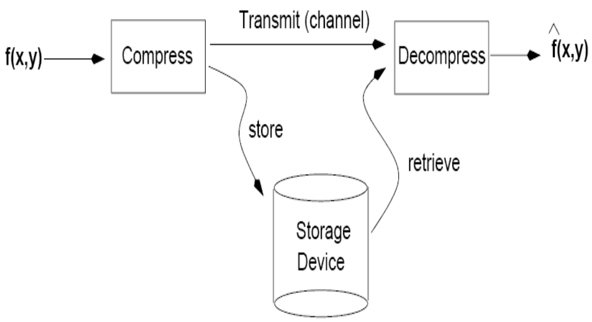


Fig.1: Image Compression

Both JPEG and wavelet belong to the general class of "transformed based lossy compression techniques." These techniques involved three steps: transformation, quantization, and encoding. Transformation is a lossless step in which image is transformed from the grayscale values in the special domain to coefficients in some other domain. No loss of information occurs in the transformation step. Quantization is the step in which loss of information occurs. It attempts to preserve the more important coefficients, while less important coefficients are roughly approximated, often as zero. Finally, these quantized coefficients are encoded.

A. *Need for image compression*

– To save memory required to store the image
– To save transmission band width
– To save transmission time

Compression is in the encoder and decompression is done in the decoder. Again encoder consists of three blocks and decoder consists of two blocks:

B. *Image Compression Model*

In the first stage of encoding process, a Mapper transforms *f(x, y)* into a format to reduce inter pixel redundancy. This operation is reversible and run length coding is an example for it. In the second stage quantizer keep the irrelevant information out of the compressed image, this operation is irreversible and results in lossy compression. In the third and final stage of encoder the symbol encoder generates fixed or variable length code to represent the quantizer output, generally variable length code is used to reduce the coding redundancy, this is reversible.

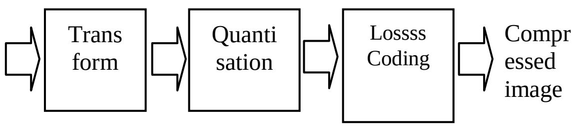


Fig. 2: Image Compression Model

III. IMAGE COMPRESSION TECHNIQUES

The image compression techniques are broadly classified into two categories depending whether or not an exact replica of the original image could be reconstructed using the compressed image .
These are:

(1) Lossless technique
(2) Lossy techniqhe

A. *Lossless compression technique*

In lossless compression techniques, the original image can be perfectly recovered from the compressed (encoded) image. These are also called noiseless since they do not add noise to the signal (image).It is also known as entropy coding since it use statistics/decomposition techniques to eliminate/minimize redundancy. Lossless compression is used only for a few applications with stringent requirements such as medical imaging.
Following techniques are included in lossless compression:

(1) Run length encoding
(2) Huffman encoding
(3) LZW coding

B. *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, relatively 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 potentially double the file size.

C. *Huffman Encoding*

The Huffman encoding algorithm is an optimal compression algorithm when only the frequency of individual letters is used to compress the data. (There are better algorithms that can use more structure of the file than just letter frequencies.) The idea behind the algorithm is that if you have some letters that are more frequent than others, it makes sense to use fewer bits to encode those letters than to encode the less frequent letters.

D. *LZW coding*

1) *LZW compression*

is named after its developers, A. Lempel and J. Ziv, with later modifications by Terry A. Welch. It is extremely effective when there are repeated patterns in the data that are widely spread. **LZW** is a general **compression** algorithm capable of working on almost any type of data.

E. *Lossy compression technique*

Lossy schemes provide much higher compression ratios than lossless schemes. Lossy schemes are widely used since the quality of the reconstructed images is adequate for most applications.

(1) Transformation Coding
(2) Vector Quantization
(3) Fractal Coding

F. *Transformation Coding*

Transform coding is a type of data compression for "natural" data like audio signals or photographic images. The transformation is typically lossy, resulting in a lower quality copy of the original input.

In transform coding, knowledge of the application is used to choose information to discard, thereby lowering its bandwidth. The remaining information can then be compressed via a variety of methods. When the output is decoded, the result may not be identical to the original input, but is expected to be close enough for the purpose of the application.

A Simple Transform Encoding procedure maybe described by the following steps for a 2x2 block of monochrome pixels:

(1) Take top left pixel as the base value for the block, pixel A.
(2) Calculate three other transformed values by taking the difference between these (respective) pixels and pixel A, i.e. B-A, C-A, D-A.
(3) Store the base pixel and the differences as the values of the transform. When the output is decoded, the result may not be identical to the original input, but is expected to be close enough for the purpose of the application. When the output is decoded, the result may not be identical to the original input, but is expected to be close enough for the purpose of the application.

G. *Vector Quantization*

Quantization is a process of representing a large possibly infinite – set of values with a much smaller set. Vector quantization (VQ) is a lossy data compression method. In the earlier days, the design of a vector quantizer (VQ) is considered to be a challenging problem due to the need for multi-dimensional integration. In 1980, Linde, Buzo, and Gray (LBG) proposed a VQ design algorithm based on a training sequence. The use of a training sequence bypasses the need for multi-dimensional integration The vector quantization algorithms for reducing the transmission bit rate or storage have been extensively investigated for speech and image signals.

H. Fractal Coding

Fractal compression is a lossy compression method for digital images, based on fractals. The method is best suited for textures and natural images, relying on the fact that parts of an image often resemble other parts of the same image. Fractal algorithms convert these parts into mathematical data called "fractal codes" which are used to recreate the encoded image. To do fractal compression, the image is divided into sub-blocks.

IV. LITERATURE

"Discrete Wavelet Transform Based Rotor Faults Detection Method for Induction Machines" was discussed by Loránd et.al in which the condition monitoring of the electrical machines can significantly reduce the costs of maintenance by allowing the early detection of faults, which could be expensive to repair. In this paper some results on non-invasive detection of rotor faults in wound rotor induction motors are presented. The applied method is the so- called motor current signature analysis (MCSA), an often cited and investigated diagnosis method. The method utilises the results of spectral analysis of the stator currents. Usually the FFT (Fast Fourier Transform) is used to obtain the power density vs. frequency plots to be analyzed. In this paper the use of a novel versatile tool of harmonic analysis, of the wavelet transform will be presented. The proposed wavelet based detection method shows a good sensitivity. The theoretical basis of the method is proved by laboratory tests. "A Study of Various Image Compression Techniques" by et.al Sonal presented paper addresses the area of image compression as it is applicable to various fields of image processing. On the basis of evaluating and analyzing the current image compression techniques this paper presents the Principal Component Analysis approach applied to image compression. PCA approach is implemented in two ways – PCA Statistical Approach & PCA Neural Network Approach. It also includes various benefits of using image compression techniques.

Another interesting technique "Fault Isolation Based On Wavelet Transform" was presented by S. Lesecq. evaluated how wavelet transform can be used to detect and isolate particular faults. The diagnostic method that is proposed is based on the stationary wavelet transform. The wavelet coefficients allow analysing the signal changes over different scales. Therefore, fault detection can be performed. Each scale is related to a particular frequency band. Thus if various faults are known to affect different frequency bands, the wavelet coefficients can be used to isolate the faults. Fuzzyfication of the wavelet coefficients is first applied, followed by the fuzzy aggregation of the fuzzyfied coefficients to make the isolation decision easy to compute and gradual. Academic examples are discussed to show the efficiency of the isolation method presented here.

There are many members in the wavelet family, Haar wavelet is one of the oldest and simplest wavelet.

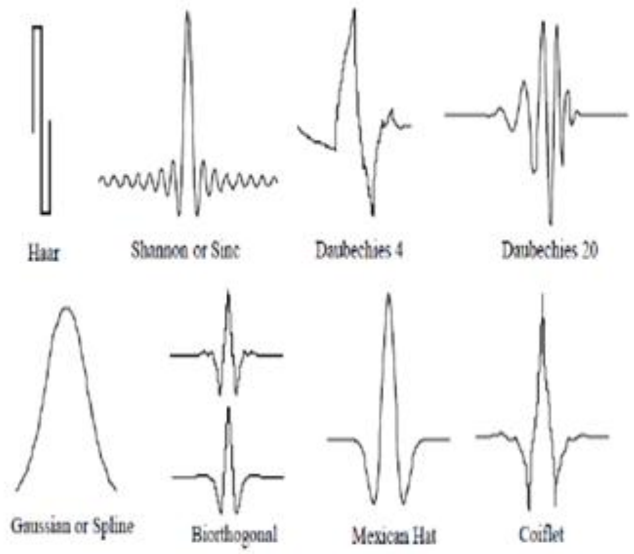


Fig.3: Different Types Of Wavelets

Daubechies wavelets are the most popular wavelets. They represent the foundations of wavelet signal processing and are used in numerous applications. The Haar, Daubechies, Symlets and Coiflets are compactly supported orthogonal wavelets. These wavelets along with Meye wavelets are capable of perfect reconstruction. The Meyer, Morlet and Mexican Hat wavelets are symmetric in shape. The wavelets are chosen based on their shape and their ability to analyze the signal in a particular application. Biorthogonal wavelet exhibits the property of linear phase, which is needed for signal and image reconstruction. By using two wavelets, one for decomposition (on the left side) and the other for reconstruction (on the right side) instead of the same single one, interesting properties are derived.

Another wavelet based image compression technique "Image Compression Using Discrete Wavelet Transform" was introduced by et.al Bhonde in which he presented an approach towards MATLAB implemention of the Discrete Wavelet Transform (DWT) for image compression. The design follows the JPEG2000 standard and can be used for both lossy and lossless compression. In order to reduce complexities of the design linear algebra view of DWT has been used in this concept. With the use of more and more digital still and moving images, huge amount of disk space is required for storage and manipulation purpose. For example, a standard 35-mmphotograph digitized at 12μm per pixel requires about 18 Mbytes of storage and one second of NTSC-quality color video requires 23 Mbytes of storage. JPEG is the most commonly used image compression standard in today's world. But researchers have found that JPEG has many limitations. In order to overcome all those limitations and to add on new improved features, ISO and ITU-T has come up with new image compression standard, which is JPEG2000. Et.al Ranjan K Senapati proposed "An Efficient Sparse 8×8 Orthogonal Transform Matrix for Color Image Compression". An efficient orthogonal sparse 8×8 transform matrix for color image compression particularly at lower bit rate applications. The transform matrix is made sufficiently sparse by appropriately inserting additional zeros into the matrix proposed by Bouguezel. The algorithm for fast computation is also developed. It is shown that the proposed transform matrix provides a 7% reduction in computation over the matrix by Bouguezel, and 45% over signed discrete cosine transform (SDCT). By using various natural test images, it is shown that the rate-distortion performance is comparable with the matrix proposed by Bouguezel and approximated DCT at low bit rates. Further, it outperforms SDCT by a large margin almost at all bit rates. Recently et.al. Krishna Kumarpresented “Analysis of Efficient Wavelet Based Volumetric Image Compression” the wavelet transform has emerged as a cutting edge technology, within the field of image compression research. Telemedicine, among other things, involves storage and transmission of medical images, popularly known as Teleradiology. Due to constraints on bandwidth and storage capacity, a medical image may be needed to be compressed before transmission/storage. This paper is focused on selecting the most appropriate wavelet transform for a given type of medical image compression. In this paper we have analyzed the behavior of different type of wavelet transforms with different type of medical images and identified the most appropriate wavelet transform that can perform optimum compression for a given type of medical imaging. To analyze the performance of the wavelet transform with the medical images at constant PSNR, we calculated SSIM and their respective percentage compression. “Image Compression Using DWT and Vector Quantization” has been carried out by et.al. Tejas S. Patel, Ideally, an image compression technique removes redundant and/or irrelevant information, and efficiently encodes what remains. Image compression is most important for efficient transmission and storage space of images. Image compression plays a most powerful role in digital image processing. In this paper, DWT and Vector quantization technique are simulated. Using different codebook size, we apply DWT-VQ technique and Extended DWT-VQ (Which is the modification algorithm) on various kinds of images. The results of simulation are shown and compared different quality parameter of it’s by applying on various images.

A. Hybrid System DWT-VQ for Image Compression

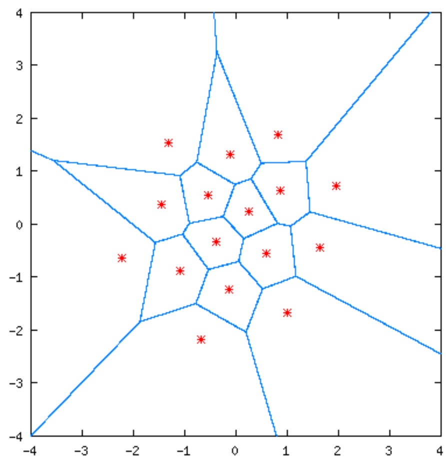
The steps of this compression shown below Steps:

(1) Apply the DWT transform and got the four bands LL, LH, HL and HH of original image.
(2) Partition the LH, HL, HH bands into 4x4 block then apply Vector Quantization on each block and result is the compressed image.

This system got high compression ratio without loss of much information because applying DWT transform we minimize the domain of codebook vector. This will helpful in achieving high compression ratio without loss of information.

This is basic system; there are more models with the change of step. We can apply DWT more than 2 level and apply different vector quantization technique.

In fig.3 there is shown hybrid model of DWT-VQ techniques for Image Compression.



Fig, 4: Hybrid System DWT-VQ for Image Compression

This preprocess step is also decrease the information loss without affecting the much compression ratio. Because after subtracting mean we got highly correlated data which means we do better quantization using vector quantization. This computation of difference matrix is discussed in paper result is shown less MSE than ordinary Vector Quantization technique.

V. CONCLUSION AND FUTURE SCOPE

Image compression scheme based on discrete wavelet transform and vector quantization is discussed in this study which provides brief review about existing techniques. A more effective and robust approach can be developed using a set of real images. Wavelets are better suited to time-limited data and wavelet based compression technique maintains better image quality by reducing errors. An enhanced hybrid technology for digital image compression can be developed on the basis of this study.

ACKNOWLEDGEMENT

I am highly grateful to Mr. Harbinder Singh Assistant Professor for giving me invaluable guidance in the field of image compression and providing me the opportunity to carry out this work further. It was the essential encouragement that enables me to pursue my work in this field.

REFERENCES

[1] Bradley J. Erickson,Armando Manduca, “Wavelet compression of medical images ,” Journal of Radiology, vol. 206, pp. 599-607, 1998.
[2] Abhishek Kaushik, Maneesha Gupta,“Analysis of Image Compression Algorithms”,International Journal of Engineering Research and Applications,march-april 2012.
[3] Anilkumar Katharotiya, Swati J. Patel Mahesh Goyani,“Comparative Analysis between DCT &DWT Techniques of Image Compression”,Journal of Information Engineering and Applications,Vol 1, No.2, 2011.
[4] Mukesh Mittal, Ruchika Lamba, Image Compression Using Vector Quantization Algorithms: A Review , *Department of Electrical & Instrumentation*

Engineering Thapar University, Patiala, India ; Volume 3, Issue 6, June 2013 .
[5] Md. Rubaiyat Hasan, "Data Compression using Huffman based LZW Encoding Technique",International Journal of Scientific &
[6] Engineering Research, Volume 2, Issue 11, 1 ISSN 2229-5518 IJSER, November 2011.
[7] Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing (2nd edition)", NJ:Prentice Hall 1992.
[8] Karen Lees, "Image compression using Wavelets", Report of M.S. 2002.
[9] Gonzalez, R.C. and Woods, R.E, "Digital Image Processing using MATLAB", Pearson Education, India,2006.
[10] LockerGnome, "Real World Application of Image Compression", 2011. Subramanya A, "Image Compression Technique,"
[11] Potentials IEEE, Vol. 20, Issue 1, pp 19-23, Feb-March 2001, David Jeff Jackson & Sidney Joel Hannah, " Comparative Analysis of image Compression
[12] Techniques," System Theory 1993, Proceedings SSST '93, 25th Southeastern Symposium,pp 513-517, 7 –9 March 1993.
[13] Hong Zhang, Xiaofei Zhang & Shun Cao, " Analysis & Evaluation of Some Image Compression Techniques," High Performance Computing in AsiaPacific
[14] Region, 2000 Proceedings, 4th Int. Conference, vol. 2, pp 799-803,14-17 May, 2000 Ming Yang & Nikolaos Bourbakis ,"An Overview of Lossless Digital Image Compression Techniques," Circuits & Systems, 2005 48th Midwest Symposiumvol. 2 IEEE ,pp 1099-1102,7 – 10 Aug, 2005
[15] Milos Klima, Karel Fliegel, "Image Compression Techniques in the field of security Technology: Examples and Discussion,"Security Technology, 2004, 38th Annual 2004 Intn. Carnahan Conference, pp 278- 284,11-14 Oct., 2004
[16] Ismail Avcibas, Nasir Memon, Bulent Sankur, Khalid Sayood, " A Progressive Lossless / Near Lossless Image Compression Algorithm,"IEEE Signal Processing Letters, vol. 9, No. 10, pp 312-314, October 2002.
[17] Dr. Charles F. Hall, " A Hybrid Image Compression Technique," Acoustics Speech & Signal Processing, IEEE International Conference on ICASSP' 85, Vol. 10, pp 149- 152, Apr, 1985
[18] Wen Shiung Chen, en- HuiYang & Zhen Zhang, " A New Efficient Image Compression Technique with Index- Matching Vector Quantization," Consumer Electronics, IEEE Transactions, Vol. 43, Issue 2, pp 173- 182, May 1997.
[19] David H. Kil and Fances Bongjoo Shin, " Reduced Dimension Image Compression And its Applications,"Image Processing, 1995, Proceedings, International Conference,Vol. 3 , pp 500-503, 23-26 Oct.,1995