

A REVIEW- PERFORMANCE EVALUATION OF DCT, DWT & N-LEVEL-HYBRID TECHNIQUE IN IMAGE PROCESSING

TABASSUM SAIFI & PRADEEP KUNAR

Computer Science, NIET, Greater Noida, Uttar Pradesh Technical University, Lucknow, India

ABSTRACT

Image compression is a process to remove the redundant information from the image so that only essential information can be stored to reduce the storage size, transmission bandwidth and transmission time. Recently the JPEG committee has released its new image coding standard, JPEG-2000, which has been based upon DWT. The essential information is extracted by various transforms techniques such that it can be reconstructed without losing quality and information of the image. In this paper a comparative study of image compression is done by three transform methods, which are Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT). The discrete Wavelet Transform is one which transform the discrete time signal to discrete wavelet representation. Basically Wavelet coding scheme is used for application where scalability and tolerable degradation are important.

KEYWORDS: Image Processing, DCT, DWT, n-Hybrid, Image Compression, Image Decompression

INTRODUCTION

Graphics, Audio and video, in its uncompressed form requires large storage capacity. In multimedia, which consist of the integration of other media, we have to compress these data so that it could be represented with less number of bits. The large size of images poses serious problem in the distribution and implementation of any software that makes extensive use of graphics. Image compression is important where image needs to be stored, transmitted over the internet. There are many advantages of image compression over the internet including less time in downloading and uploading the image, require lesser bandwidth. In image compression methodology, generally spectral and spatial redundancy should be reduced as much as possible. There are many applications where the image compression is used,

Applications are like Health industries, retail store, security industries, museums and galleries etc. The compression scheme is divided in to two broad categories as Lossy Image Compression and Lossless Compression. In lossless compression scheme, the original image can be recovered from the compressed image. However lossless image compression is used for archival purpose, medical imaging, technical drawing etc. In lossy image compression, compressed image is different from the original image. for this purpose many techniques i.e scalar/vector quantization, differential encoding, predictive image coding, transform coding have been introduced. Among all these coding, transform coding is most efficient specially at low bit rate[1]. Transform coding relies on the principle that the pixels on the image shows certain pixels. Consequently these correlation can be exploited to predict the value of pixels from its respective neighbors. A transformation is therefore, defined to map this spatial (correlated) data into transformed (uncorrelated) coefficient. Clearly, the transformation should utilize the fact that the information content of an individual pixel is relatively small i.e, to a large extent visual contribution of pixel can be predict using its neighbor. Depending on the

compression techniques the image can be constructed with or without perceptual loss. Transform coding, which applies a Fourier-related transform such as DWT are the most commonly used approach [3]. In this paper we made a study of the three transform coding techniques, viz. DCT, DWT and n-level hybrid which is the combination of both DCT and DWT.

This paper is organized as follows : Section II explains Discrete Cosine Transform algorithm, Section III describe the Discrete Wavelet Transform algorithm (DWT) and Section IV describe the N-Level Hybrid compression scheme and there is conclusion in Section V.

Discrete Cosine Transform (DCT)

Several techniques can transform an image in to frequency domain such as DCT, DFT [1] and Wavelet Transform. Each transform has its advantages, First here the Transform Technique is discussed: the most common definition of DCT says, it is a technique which converts signal into elementary frequency component.

The definition of a 1-D sequence of Length N is:

$$Y[k] = c[k] \sum_{n=0}^{N-1} X[n] \cos \left[\frac{(2n+1)k\pi}{2N} \right] \quad (1)$$

For $K=0,1,2,3,4,5,\dots,N-1$, similarly the inverse DCT transform is defined as:

$$X[n] = \sum_{K=0}^{N-1} C[K] Y[K] \cos \left[\frac{(2n+1)k\pi}{2N} \right] \quad (2)$$

For $K=0,1,2,3,\dots,N-1$. In both equation (1) and (2) $C[n]$ is defined as:

$$c[N] = \begin{cases} \sqrt{\frac{1}{N}} & \text{for } N = 0 \\ \sqrt{\frac{2}{N}} & \text{for } N = 1,2,3, \dots, N-1 \end{cases} \quad (3)$$

Discrete cosine transform (DCT) is widely used in image processing, especially for compression algorithm for encoding and decoding in DCT technique is shown below.

Encoding System

There are four steps in DCT technique to encode or compress the image.

Step 1: The image is broken into $N*N$ blocks of pixels. Here N may be 4, 8, 16, etc.

Step 2: Working from left to right, top to bottom, the DCT is applied to each block.

Step 3: Each block's elements are compressed through quantization means dividing by some specific value.

Step 4: The array of compressed blocks that constitute the image is stored in a drastically reduced amount of space.

So first the whole image is divided into small $N*N$ blocks then DCT is applied on these blocks. After that for reducing the storage space DCT coefficients [5] are quantized through dividing by some value or by quantization matrix. So that large value is become small and it need small size of space. This step is a lossy step. So selection of quantization value or quantization matrix is affect the entropy and compression ratio. If we take small value for quantization then we get the better quality or less MSE (Mean Square Error) but less compression ratio. Block size value also affects quality and

compression ratio. Simply the higher the block size higher the compression ratio but with loss of more information and quality.

Decoding System

Decoding system is the exact reverse process of encoding. There are four steps for getting the original image not exact but identical to original from compressed image.

Step 1: Load compressed image from disk.

Step 2: Image is broken into $N \times N$ blocks of pixels.

Step 3: Each block is de-quantized by applying reverse process of quantization.

Step 4: Now apply inverse DCT on each block. And combine these blocks into an image which is identical to the original image.

In this decoding process, we have to keep N 's value same as it used in encoding process. Then we do de-quantization process by multiplying with quantization value or quantization matrix. As earlier said that this is lossy technique so output image is not exact copy of original image but it is same as original image. So this process' efficiency is measure by compression ratio. Compression ratio [3] is defined by ratio of storage bits of original image and storage bits of compressed image.

$$cr = \frac{n1}{n2} \quad (4)$$

Where $n1$ is number of bits to store original image and $n2$ is number of bits to store compressed image.

Loss of information is measure by Mean square Error (MSE)[1,5] between reconstructed image and original image. If MSE of reconstructed image to original image is greater than the information lost is more.

$$MSE = \sum_{i=1}^M \sum_{j=1}^N (x(i, j) - x'(i, j))^2 \quad (5)$$

Where M, N is dimension of image. $x(i, j)$ is pixel value of (i, j) coordinate of original image while $x'(i, j)$ is the reconstructed image's pixel value.

Discrete Wavelet Transform (DWT)

Wavelets Transform has become an important method for image compression. Wavelet based coding provides substantial improvement in picture quality at high compression ratio mainly due to better energy compaction property of wavelet transform. Wavelet analysis is based on the decomposition of a signal using an orthonormal family of basic function[9]. Wavelet are well suited for the analysis of transient and time-varying signals[10]. The wavelet transform has been developed to overcome the problem of resolution. Informally, wavelet transform partition a signal into a set of functions called wavelet. The wavelet transform is computed separately for different segment of the time domain signal at different frequencies. Wavelet based coding is more robust where the possibilities of transmission error and decoding error is more. As, wavelet has multi-resolution nature, they are mostly used in that application where scalability and tolerable degradation are important.

In wavelet analysis, we generally talk about approximation and details. The approximation are the high scale, low

frequency component of the signal, the details are the low scale, and high frequency component.

Multi Resolution nature of the Wavelet Transform:- Multi Resolution means that the image can be represent simultaneously at different levels. The basic idea behind the 2D(Two Dimension) says that: Based on frequency sub bands, image is first decomposed into four parts, by sub sampling horizontal and vertical channels using sub bands filters, and the channels are named as: LOW –LOW(LL), LOW HIGH(LH), HIGH- LOW(HL), HIGH- HIGH (HH).At every level of decomposition the horizontal data is filtered, and then the approximation and details produced from this are filtered on columns. At every level, four sub-images are obtained; the approximation, the vertical detail, the horizontal detail and the diagonal detail. Wavelet function for 2-D DWT can be obtained by multiplying wavelet functions ($\psi(x,y)$) and scaling function ($\phi(x,y)$).

After first level decomposition we get four details of image those are,

Approximate details – $\psi(x, y) = \phi(x) \phi(y)$

Horizontal details – $\psi(x, y) = \phi(x) \psi(y)$

Vertical details – $\psi(x, y) = \psi(x) \phi(y)$

Diagonal details – $\psi(x, y) = \psi(x) \psi(y)$

he data in Sub band ‘HL’ is achieved by Low Pass filtering of the row, and High pass filtering of the column. Same as data in sub band ‘LH’ is achieved by High Pass filtering of the row, Low pass filtering of the column.[11]

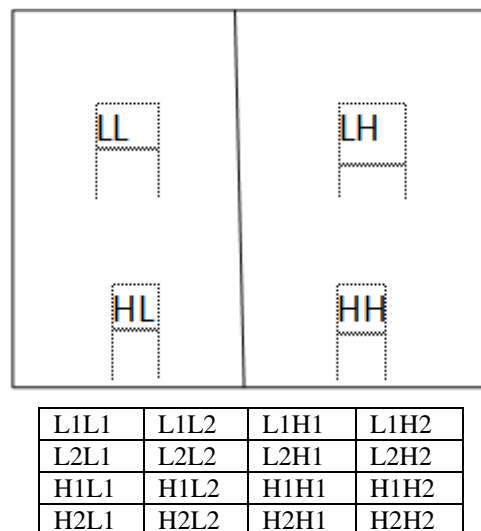


Figure 1(a): Wavelet Filter Decomposition(Scalar Wavelet), (b) Multi Wavelets

Proposed N- Level HYBRID TRANSFORMATION

The objective of the N-level Hybrid technique is to take the advantages of both Techniques DCT, DWT and Hybrid techniques. As we know there are 2 types of sections are available in the image, so, the original image of size 256X256, is divided in to background and foreground sections, then sub divided in to 8X8 blocks. After this process of division, we use the 2D-DWT decomposing scheme for decomposing the each blocks, and we get the Low Frequency

Coefficient and High Frequency coefficient. There are only one Low frequency coefficient LL and three High Frequency Coefficient HH,HL, LH. And then, low frequency coefficient are passed to the next stage, where high frequencies coefficient like HL, LH, HH are discarded. In the next step further decomposition is done on the LL by using 2D – DWT, and again LH,HL,HH is discarded.

Now, we applied DCT on the remaining 4X4 blocks, LL coefficient and achieve higher compression ratio. After all these stages, we applies the N-level hybrid technique on the 4X4 blocks, and again do the same 1and 2D- DWT Technique on this block. Then the image is compressed

The original image can be reconstructed by applying the inverse procedure on the compressed image.

Compression by using this technique produce a good quality image and most of the image information is not loss. It has a good compression ratio as compared to the JPEG and JPEG200.

We have evaluate these techniques on the basis of below parameter which are described below

PSNR

It is a widely used method for measuring the Compressed image. It is very simple and effective method and easy to compute.

PSNR can b evaluated as:

$$\text{PSNR} = 10 \log_{10} \frac{I^2}{\text{MSE}} \quad (3)$$

Where I is the Intensity level.

Where MSE is the Mean Squared Error, it is another performance evaluation parameter used for compression.

It is one of the important performance evaluation parameter used for measuring the quality of image. It compares the original image with the reconstructed image and then shows the level of distortion.

$$\text{MSE} = \frac{1}{MN} \sum_{i=1}^M \sum_{j=1}^n (A_{i,j} - B_{i,j})^2$$

Where A is a original image of size NXN

B, is a reconstructed image of size NXN

CR

It is mostly used and powerful method for measuring the reduction of details coefficient of the image.

It can be computed as :

$$\text{CR} = \frac{\text{Discarded data}}{\text{Original data}}$$

It is very important concept in image compression, because it is important to know how much important coefficient are discarded from the input image so that the critical information is preserved in original image.

CONCLUSIONS

In this paper we have studied various compression technique such that Discrete Cosine Transform DCT and Discrete Wavelet Transform Technique DWT. These techniques are used for compression the image when we have to transmit the image over the network. Here the proposed technique N-level Hybrid techniques us used to compressed the image, which uses the benefits the both of the images. And compressed the image with better compression ratio as compared to the DCT and DWT techniques. It also revealed that the N-level Hybrid techniques compress the image with less loss of information content in the image. It also observed that the when image is compressed by using N-level hybrid technique it require less storage space for storing the image and less bandwidth for transmitting the image over the internet.

REFRECNCES

- I. R. C. Gonzalez and R. E. Woods, "Digital Image Processing", Reading, MA: Addison Wesley, 2004
- II. David Salomon, Data Compression, The Complete Reference, 2nd Edition Springer-Verlag 1998
- III. Digital Compression and coding of Continuous-tone still images, part 1, requirements and Guidelines. ISO/IEC JTC1 Draft International Standard 10918-1, Nov. 1991
- IV. G. K. Wallace, "The JPEG Still Picture Compression Standard", IEEE Trans. On Consumer Electronics, vol.38, No.1, pp. xviii – xxxiv, Feb 1992
- V. S. Martucea, "Symmetric convolution and the discrete sine and cosine transform", IEEE Transaction on Signal Processing, vol. 42, p. 1038-1051, May' 1994
- VI. R. M. Gray, D. L. Neuhoff, "Quantization", IEEE Trans. Inform. Theory, Vol. 44, No. 6, 1998
- VII. N. Ahmed, T. Natrajan, and K. R. Rao, "Discrete Cosine Transform", IEEE Transactions on Computers, vol. 23, July 1989.
- VIII. Pennebaker, W. B. and Mitchell, J. L. JPEG - Still Image Data Compression Standards, Van Nostrand Reinhold, 1993
- IX. Amara Graps. An introduction to wavelets, *IEEE computational science and engineering*, summer 1995, Vol 2, No.2.
- X. Ingrid Daubechies, Ten Lectures on Wavelets, SIAM, Philadelphia PA, 1st Edition, 1992.
- XI. M. Ashok, Image Compression Techniques Using Modified high quality Multi wavelets, (*IJACSA*) *International Journal of Advanced Computer Science and Applications*, Vol. 2, No. 7, 2011.