Section A -Research paper

E-ISSN: 2063-5346

Discrete Wavelet Transform (DWT) Based Image Compression

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Article History: Received: 10.03.2023 Revised: 18.04.2023 Accepted: 22.05.2023

Abstract: Image compression is the process of reducing the required amount to represent an image and one of the most powerful and useful technique of digital image processing. Here in this paper we have discussed some fundamental concepts behind image compression techniques and apply wavelet transform for the compression of images. Wavelet transform is the most popular transform of time frequency signals. In this paper wavelets – haar, daubechies, biorthogonal and coiflet of wavelet families are used for compression. A comparative study is also done by Peak signal to noise ratio (PSNR), Mean square error (MSE), Compression Ratio (CR) etc. quality measuring parameters of images.

Keywords: Redundancy, Image compression, DWT, PSNR, CR, MSE

Introduction

Image compression is considered as one of the key of fast progress in the field of Digital image processing [2]. By the process of compression, the information contained in the image is represented in compact [5] form. Data storage is required in various offices, hospitals,

institutions and many more. It also plays a vital role in smart phones and tablets [15]. Many users and businessmen need storage to preserve information to maintain records. For example image data requires a lot of space to store and time to transmit the data. Upto some extent this problem can be resolved by increasing the bandwidth but the relatively high cost restrict the consumer. Therefore compression is necessary and essential for creating image files with manageable and transmittable size.

Mainly Image compression techniques are broadly divided into two categories -Lossless and lossy compression techniques. As the name represents, In lossless compression the image reproduced after compression is exactly original whereas in lossy compression technique the algorithm losses some information but the lossy part is not noticed by the receiver or human eye is not able to visualize that changes. For example in the case of image data depending upon the required quality of image, lossy data [12] is acceptable upto some extent.

For a good understanding of the wavelet based image compression techniques, some basic terms are need to introduce. A digital image is defined as a two-dimentional function [5], f(x,y), where x and y are spatial coordinates and the value of f at a particular spatial coordinate (x,y) is called the intensity value or pixel value of the gray level of the image at that point. The two dimentional intensity array of the image data consists of mainly three types of data redundancies [2] that can be identified and encountered during compression.

1. **Code or symbol redundancy**: Every piece of information in the image is a sequence of code symbols (letters, numbers etc.). The 8 bit [2] code used to represent the pixel values in most 2-D intensity array consists of more bits than the required to represent them.
2. **Spatial redundancy:** This redundancy is also known as inter pixel redundancy. In most of the two dimensional intensity data of the images, the pixel values are similar or correlated to the neighboring pixels. By reducing the redundancy associated with the correlated pixel values, a two dimensional intensity array can be restored in a more efficient way.
3. **Irrelevant redundancy**: In the context of image compression the two dimensional intensity data of the image contains information that is not noticed by the human visual system. This information is comparatively less important [13] for visual image

processing. By the elimination of such information, the compression is achieved upto some extent.

Discrete Wavelet Transform (DWT)

Wavelet based image compression algorithm is one of the most effective algorithm among the all available algorithms for compression. In 1984, due to the limited application of Fourier transform, wavelet transform was first initiated by Morlet. Fourier transform is used to analyze the signal for the frequency information whereas the wavelet transform is used to analyze both the time and frequency information[13] simultaneously. In general the wavelet transform can analyze the signal for all the frequency range by the transformation equation. But it will take lots of time and not necessary to compute the signal for all frequencies. DWT is a transform in which almost half of the samples are required to represent a signal into its original form [7] (Nyquist's theorem). DWT works on the concept of multiresolution analysis.

DWT based image compression techniques have a remarkable advantage over the other existing transforms like discrete fourier transform(DFT), short time fourier transform(STFT), discrete cosine transform(DCT) etc. For the compression purpose the two dimensional image data is passed through a series of low pass filter and high pass filter under the sub band coding scheme. These filters are applied along the rows and then along the coloum one by one.

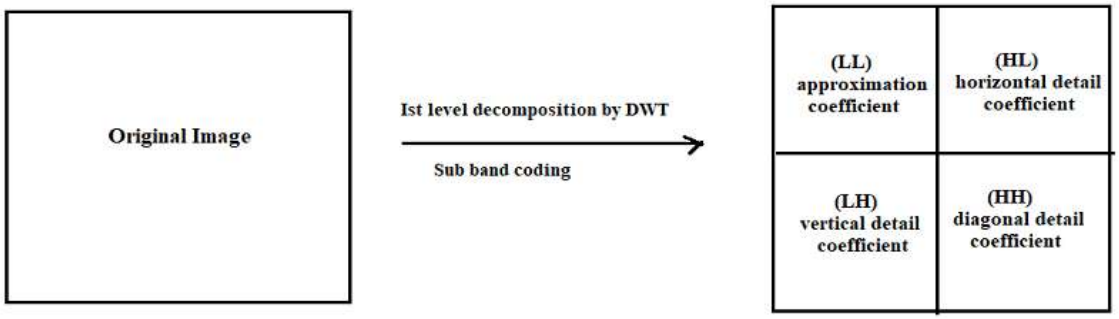

Fig. 1 First level decomposition by DWT

The image received from the filter bank is decomposed into four subimages namely LL, LH. HL and HH. The sub image LL is the approximation coefficients of the image and shows the general trend[14] of the image whereas the rest three sub images LH, HL, HH are the detailed coefficients.

Literature Survey

Anil K. katharotiya et al.[6] represented the two compression techniques DCT and DWT for compression of different images and the simulated results are shown and compared by various image quality measuring parameters. It is found that both the techniques have their own advantages but still DWT shows more efficient results as compare to th DCT.

Rehna V. J. et al.**[1]** provided a detailed survey on the various wavelet based coding techniques such as Embedded Zerotree wavelet (EZW), the Embedded Predictive Wavelet Image Coder (EPWIC), the Adaptive Scanned Wavelet Difference Reduction (ASWDR), Embedded Block Coding with Optimized Truncation (EBCOT), Space Frequency Quantisation (SFQ) coding schemes etc. In this paper the discussion on various techniques were presented for the algorithm implementation. Finally concluded that the wavelet based compression techniques are superior to other techniques due to its multiresolution character and high quality energy compaction of reconstructed images.

Anjli Bakshi et al.[3] applied the coif0, coif2, coif6 and coif8 wavelets for the compression of image and compare the four wavelets through the parameters like Peak Signal to Noise Ratio (PSNR), Normalized Absolute Errors (NAE), Mean Square Error (MSE) and Compression Ratio (CR).

A. Grinsted et al. [4] in their paper applied the cross wavelet transform and wavelet coherence to analyze geophysical time series simultaneously. They apply this concept to the Arctic Oscillation index and the Baltic maximum sea ice extent record and demonstrated the phase angle statistics and time frequency relationship between the two time series. The statistical significance against the noise background is assessed by the Monte Carlo Methods.

Experimental Methodology

In the proposed methodology, we have taken three different types of images – Image 1(Penguin.jpg), Image 2 (Rose.png) and Image 3 (Apple.tiff) from different web resourses

[8],[9],[10] and applied the DWT decomposition based compression on the following images. The algorithm is implemented in MATLAB program through the following steps-

I – Load the original image for input.

II – Now convert the image from RGB to grey and then make it square in size.

III – Apply the forward Discrete wavelet transform with different wavelets – Haar, daubechies2, biorthogonal4.4 and coiflet1[3] and set the decomposition level at one by the command 'wavedec2' on the selected images.

IV – Now computes the approximation coefficient of Ist level decomposition of image by appcoef2 command and display the compressed image.

V – Implement the reverse wavelet transform and get the reconstructed coefficients of wavelet decomposed image.

VI – Take the reconstructed image to compute the image quality parameters.

VII – Analyze the various quality parameters like PSNR, MSE, CR, maximum squared error (MAXERR) and ratio of squared norms (L2RAT).

VIII – Compare these analyzed results of different wavelets.

IX – Do the same process for other images and compare the results.

X – Algorithm ends.

Result And Discussion

In the proposed work, the discussed algorithm is applied on the selected images in MATLAB by various wavelet toolbox functions [11]. The original image is compressed and reconstructed by the wavelet functions 'wavedec2' and 'wrcoef2' respectively. The original and the grey scale conversion of three selected images is shown in Fig.2, Fig. 3 and Fig. 4.

(a) **(b)**

Fig.2 a) Original image : Penguin b) Gray Scale Image : Penguin

(a) **(b)**

Fig.3 a) Original image : Rose b) Gray Scale Image : Rose

(a) **(b)**

Fig.4 a) Original image :Apple b) Gray Scale Image : Apple

Fig. 5, Fig. 6 and Fig. 7 shows the reconstructed image obtained by first level wavelet decomposition of the four wavelets.

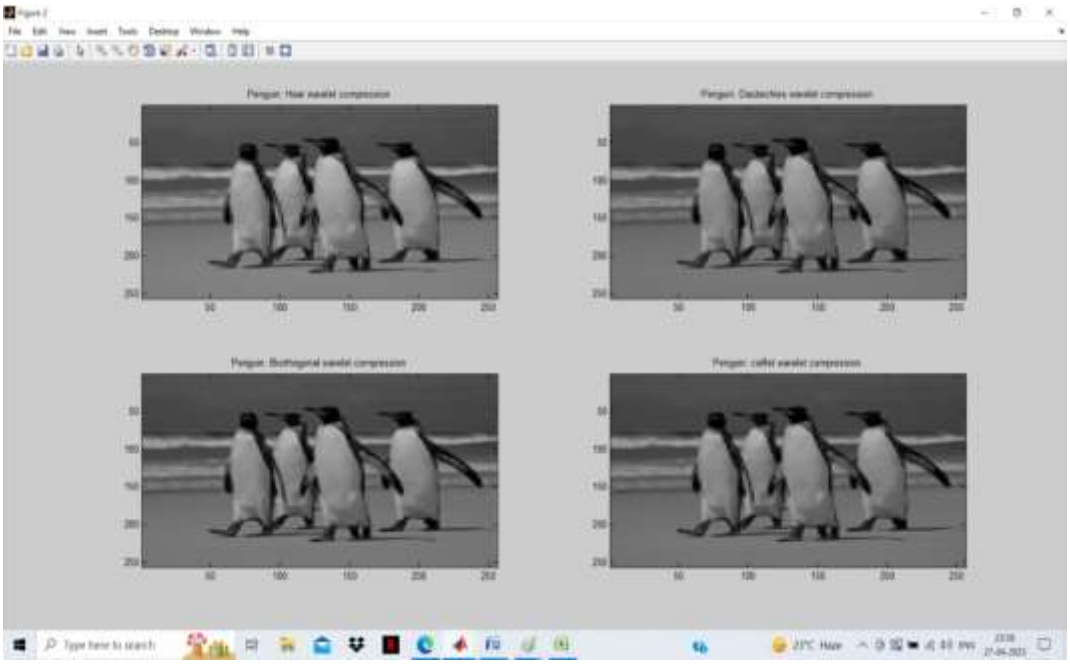

Fig. 5 Reconstructed Image of Image1(penguin.jpg) by different wavelets at decomposition level 1

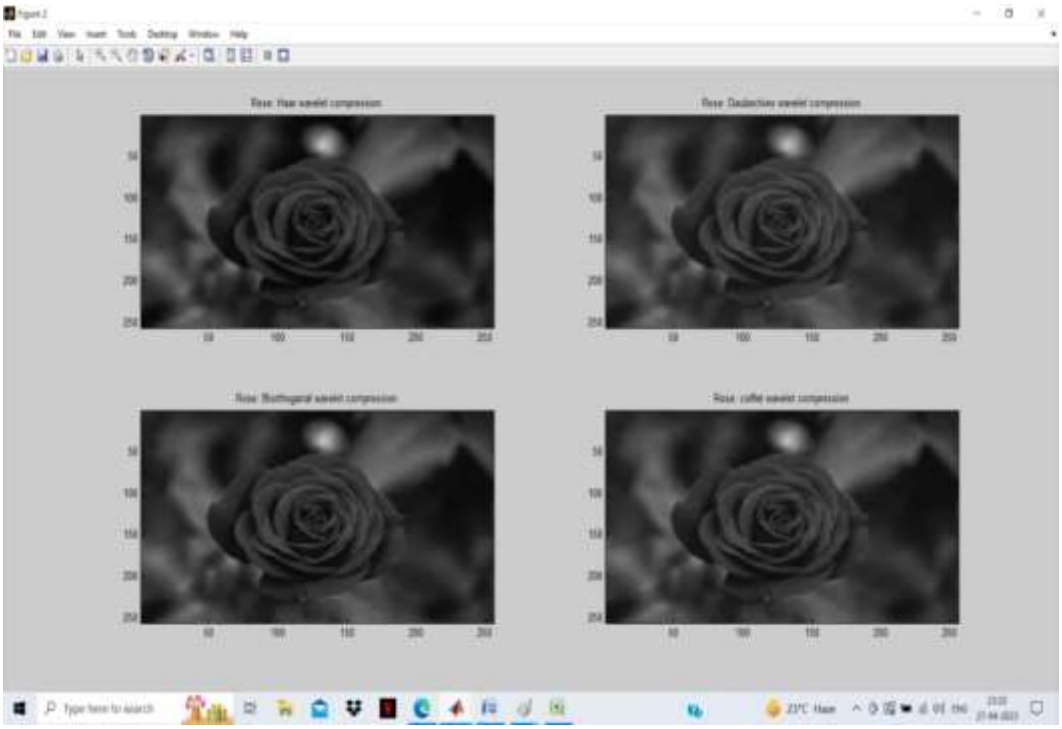

Fig. 6 Reconstructed Image of Image2(Rose.png) by different wavelets at decomposition level 1

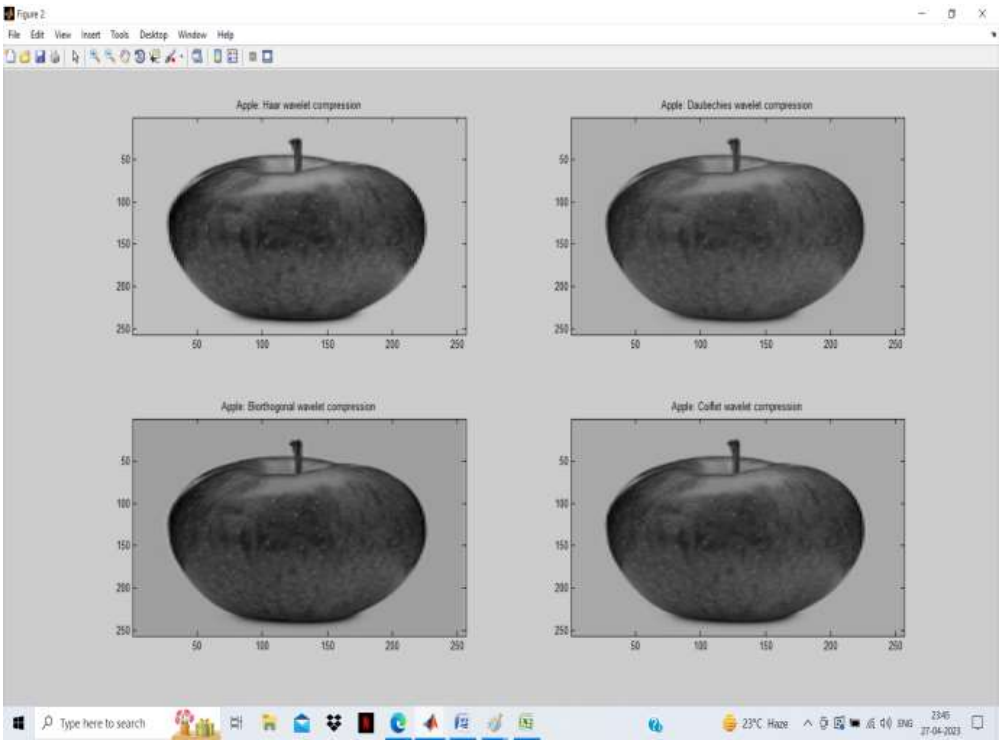

Fig. 7 Reconstructed Image of Image3 (Apple.tiff) by different wavelets at decomposition level 1

The results based on DWT transform using wavelets Haar, db2, biorthogonal4.4 and coiflet1 in terms of parameters PSNR, MSE, CR, MAXERR and L2RAT is shown in Table 1.

Image Sample	Wavelet Name	PSNR(db)	MSE	CR(%)	MAXERR	L2RAT
Image 1 (Penguin.jpg)	Haar	27.2633	122.1085	96.59	113	0.9943
	Daubechies2	29.0271	81.3532		104.6195	0.9962
	Biorthogonal4.4	30.0482	64.3066		97.0396	0.9968
	Coiflet1	29.1029	79.9442		98.8169	0.9963
Image 2 (Rose.png)	Haar	38.7416	8.688	56.52	32	0.9972
	Daubechies2	41.3934	4.7179		27.5134	0.9985
	Biorthogonal4.4	42.5895	3.5821		29.0183	0.9987
	Coiflet1	41.2507	4.8754		32.0581	0.9984
Image 3 (Apple.tiff)	Haar	30.6151	56.4384	63.92	124.5	0.9986
	Daubechies2	32.5392	36.2374		83.6595	0.9991
	Biorthogonal4.4	33.5081	28.9916		70.7493	0.9992
	Coiflet1	32.6596	35.2472		79.9381	0.9991

Table 1: Result analysis of image compression for various wavelet transform

It is seen in the table that we have applied the four wavelets on three different images. From the results of the calculated values of image quality measuring parameters, it is observed that

biorthogonal4.4 wavelet has shown the best results in terms of PSNR and MSE values. For the better compression the peak signal to noise ratio must be higher value as possible and mean square error must be lower as possible. In the results shown in table 1, biorthogonal4.4 wavelet shows the highest value of PSNR and lowest value of MSE among the four wavelets in all the three images. It is also observed from the obtained results that various wavelet transforms gives the same value of compression ratio for a particular image.

Further we have also plotted and compare the bar graph of PSNR and MSE values of various wavelet transform for Image 1, 2 and 3 as shown in Fig. 8 and Fig. 9 respectively.

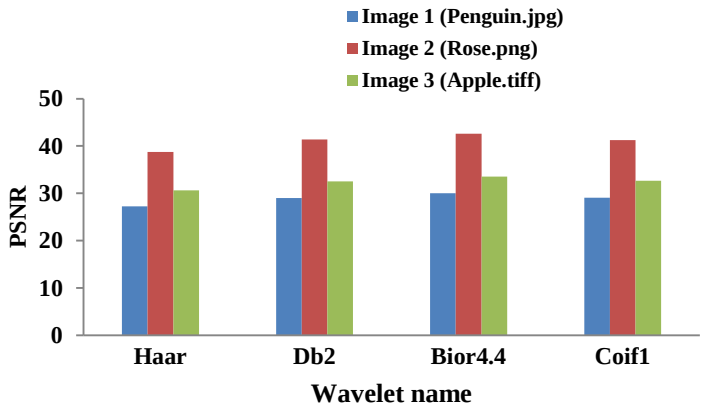

Fig. 8 Compiled Bar graph of PSNR values of various wavelet transform

It is clear from Fig. 8 and Fig. 9 that Image 2(Rose) which is a png file, gives the best PSNR and MSE values as compare to the jpg and tiff files.

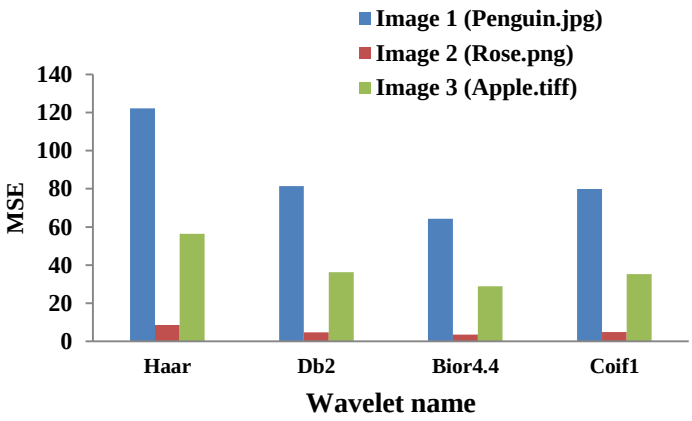

Fig. 9 Compiled Bar graph of MSE values of various wavelet transform

Conclusion

In this paper wavelet based image compression technique is proposed on different type of images using Haar, db2, bior4.4 and coef1 wavelet transform. Proposed method successfully compressed the images and it is concluded from the observed results that biorthogonal4.4 wavelet provides the best results. It is also found that png files after compression provides most effective results in terms of PSNR and MSE values.

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