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IMAGE COMPRESSION USING MODIFIED FAST HAAR WAVELET TRANSFORM AND SET PARTITIONING IN HIERARCHICAL TREE

V.Priya Department of Computer Science, Vellalar College for Women, Erode, TamilNadu, India.

Dr.B.Ananthi Department of Computer Science, Vellalar College for Women, Erode, TamilNadu, India.

ABSTRACT *The image is actually a kind of redundant data. Using compression techniques it is possible to remove some of the redundant data or information contained in images.Wavelet transform has become an important technique for image compression. Wavelet based techniques provide substantial improvement in image quality at high compression ratios. This paper aims at various analyses of Modified Fast HaarWavelet Transform (MFHWT) filter in Wavelet Packet Transform (WPT) using Set Partitioning in Hierarchical Tree (SPIHT) algorithm for encoding and decoding the process. Finally the comparison is made between different images using error metric parameters such as Compression Ratio (CR), Peak Signal Noise Ratio (PSNR) and Mean Square Error (MSE) values.*

KEYWORDS : WPT, MFHT, SPIHT, PSNR, CR, MSE.

1. INTRODUCTION

Image compression, the art and science of reducing the amount of data required to represent an image at good quality. With the enormous development in the field of digital computer, one has to equip with informatio n every time which often presents more difficulties. So, the digital information or data must be stored, transmitted and retrieved in an efficient and effective manner. Wavelets provide a mathematical tool for encoding and decoding the information in such a way that it is layered according to level of details. This layering prerequisitesi milarity at several stages and stored using a less space than the original data for practical use.

2. WAVELET TRANSFORM

A more recent transformation called wavelet transformation, which make even easier to compress, transmit and analyze many images. Wavelets are the functions that are concentrated in time as well as in the frequency around a certain point. Wavelet transform exploitson both the spatial and frequency interrelationship of data by dilations and translations of mother wavelet on the input data. The function of wavelet transform is

$$\gamma(s,\tau) = \int f(t)\Psi^{*}_{s,\tau}(t)dt \qquad (1)$$

where$\gamma(s,\tau)$ is coefficient of wavelet with scale s and time τ, $\Psi^{*}_{(s,\tau)}$ is a complex conjugate wavelet with scale and time and t is a time series. The function of inverse wavelet transform is

$f(t)=\iint \gamma(s,\tau)\ \Psi_{(s,\tau)}(t)d\tau ds$(2)

where t is a time series,$\gamma(s,\tau)$ is coefficients of wavelets, $\Psi_{s,\tau}$ is a wavelet with scale s and time τ. All the wavelets derived from the mother wavelet that is

$$\Psi_{s,\tau}(t) = \frac{1}{\sqrt{s}}\Psi\left(\frac{t-\tau}{s}\right) \qquad (3)$$

whereΨ is a mother wavelet and S is a wavelength

3. WAVELET PACKET TRANSFORM

Wavelet packets were introduced by Coifman, Meyer and Wickerhauser by widely applicable tothe link between multiscaleapproximation and wavelets [2] [3]. The fundamental idea of the wavelet packet is to split the coefficient values. Wavelet packets are the wavelet transforms in which the details are iteratively filtered [5]. The wavelet transform concern the wavelet transform step to the low pass filter results. The wavelet packet transform concern the wavelet transform step to both the low pass (approximations) and the high pass (details) results. The wavelet packet transform can be seemed as a tree. The root of the tree is the master data set. The next level of the tree is the result of process of the wavelet transform. Upcoming levels in the tree are established by recursively (using a rule) applying the wavelet transform step to the low and high pass filter results of the previous wavelet transform step. The figure 1 shows the two level decomposition of WPT.

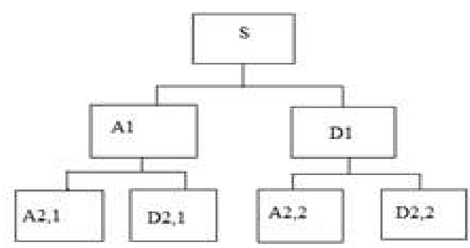

Figure 1: Two Level Wavelet Packet Transform

4. PROPOSED WORK

The block diagram showed in the figure 2 shows the actual implementation of the proposed work.

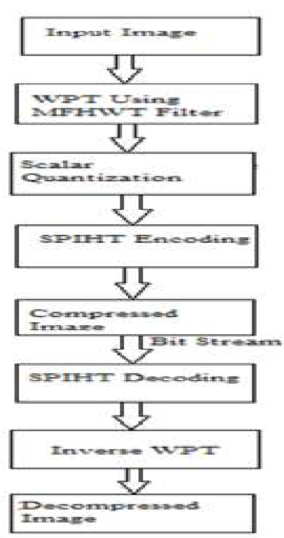

Figure 2: Architecture of Proposed Work

4.1 MODIFIED FASR HAAR WAVELET TRANSFORM (MFHWT)

The Wavelet Packet Transform (WPT) method is a general of wavelet decomposition that offers a substantial signal analysis. Wavelet packet atoms are waveforms subjected by three naturally explicated parameters position, scale and frequency [6]. Here two level WPT is used. The wavelet transform have various families. The most important wavelets families are Haar, Symlets,Daubechies, Coiflets, and biorthogo-nal. The Haar Transform (HT) is one of the fundamental transformations. A HT decomposes each signal into two elements, one is called average (approximation) and the other is called difference (detail). The function of Haar Transform for average that is approximation is

$$a_n = \frac{f_{2n-1}+f_{2n}}{\sqrt{2}}, n = 1,2,3,..N/2 \quad (4)$$

and for difference that is detail is

$$d_n = \frac{f_{2n-1}-f_{2n}}{\sqrt{2}}, n = 1,2,3,..N/2 \quad (5)$$

Instead of using the two nodes, here in the proposed work four nodes are used that is Modified Fast Haar Wavelet Transform (MFHWT) used to reduce the calculation work with faster and in efficient manner [4]. The formula MFHWT for average is

$$a_m = \frac{f_{4m-3}+f_{4m-2}+f_{4m-1}+f_{4m}}{4}, m = 1,2,3,..N/4 \quad (6)$$

and for difference is calculated as

$$d_m = \begin{cases} \frac{(f_{4m-3}+f_{4m-2})-(f_{4m-1}+f_{4m})}{4} & ,m=1,2,3..N/4 \\ 0 & ,m = \frac{N}{2},\ldots N \end{cases} \quad (7)$$

MFHWT is used to reduce the memory requirements and the amount of ineptmotion of Haar coefficients. Thus MFHWT reduce the calculation work of Haar Transform.

4.2 SCALAR QUANTIZATION

Quantization refers to the process of approaching the continuous set of values in the image data with a finite set of values. The input given to a quantizer is the master (original) data, and the output is always one among a finite number of levels. The quantizer is a taskto keep irrelevant information out of the compressed representation. In Scalar Quantization (SQ), each input symbol is treated separately in producing the output [11]. If the input area is divided into levels of equal spacing, then the quantizer is known as uniform quantizer, and if not, it is known as non-uniform quantizer. A uniform quantizer can be easily identify by a number that is less than or equal to the number in a given set. Implementing the uniform quantizer is easier than a non-uniform quantizer. In this proposed work SQ has been applied for WPT.

4.3 SET PARTITIONING IN HIERARCHICAL TREE (SPIHT)

SPIHT is one of the powerful algorithms of image compression. The SPIHT algorithm is used to encode and decode the coefficients of wavelet [7] [8] [9]. The SPIHT algorithm uses a partitioning of the tree in a manner that tends to keep insignificant coefficients together in larger subsets. The tree structure of SPIHT is shown in the figure 3. The partitioning decisions are binary decisions that are transmitted to the decoder, providing a significant map. The thresholds used for checking significance are powers of two, so in essence the SPIHT algorithm sends the bit stream that is the binary representation of the integer value of the wavelet coefficients. In SPIHT the sorting pass coefficients are categorizes into three lists: List of Insignificant Sets (LIS) are the set of coefficients having magnitude smaller than the threshold. List of Insignificant Pixels (LIP) is the coefficients having magnitude smaller than the threshold. List of significant Pixels (LSP) are the pixels those magnitude is larger than that of threshold.

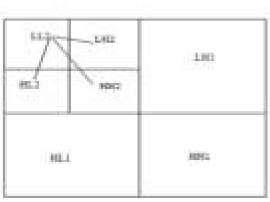

Figure 3: Tree structure of SPIHT

5. EXPERIMENTAL RESULT

The proposed algorithm is tested on the different still images [11]. To test the effectiveness of the image quality different parameters are used. They are Peak Signal Noise Ratio (PSNR), Compression Ratio (CR) and Mean Square Error (MSE). PSNR is calculated by

$$PSNR = 10\log_{10}\left[\frac{255^2}{MSE}\right] \quad (8)$$

where MSE is

$$MSE = \frac{Sum(Sum(a-b)^2)}{M \times N} \quad (9)$$

where a = input image size
b = output image size
M = number of rows
N = number of columns

Compression Ratio is one of several measures that are commonly used to express the efficiency of a compression method. It is calculated as

$$CR = \frac{outputstream}{inputstream} \quad (10)$$

The MSE is the cumulative squared error between the compressed and the original input image, whereas PSNR is a measure of the peak error. The table 1 shows the experimental results of different images using the above mentioned parameters.

Table 1: Experimental Result

S.No	Image Name	CR	PSNR dB	MSE
1	Brain	0.9984	38.28	9.654
2	Baby	1.0005	45.28	1.929
3	Dolphin	1.0003	36.74	13.77
4	Loin	1.0001	34.49	23.14
5	Cameraman	1.0003	39.27	7.685

6. CONCLUSION

Image compression using WPT with SPIHT seems to be powerful for still images. With compression there may be information lost. In this consider, wavelet analysis can be seen to be far snobbish. The MFHWT is faster and reduce the calculation work. In MFHWT the values of average and difference are one level ahead than the haar transform. So it occupy only less memory space to store. One important feature of SPIHT is that it uses a progressive transmission. Compression algorithm not only raises the coding efficiency and also the quality of the reconstructed image. It also reduces the image encoding time. Therefore, in the area of image processing the proposed methodology has a very broad application prospects in medical image, cryptography and also in segmentation.

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