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Image Compression Using Wavelet Based Various Algorithms

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Abstract— Five different Wavelet based Image Compression techniques are analyzed. The techniques involved in the comparison process are Embedded Zero tree Wavelet (ezw), Set Partitioning In Hierarchical Trees (Spiht), Spatial-orientation Tree Wavelet (stw), Wavelet Difference Reduction (wdr), Adaptively Scanned Wavelet Difference Reduction (aswdr) . Here, there are five types of Wavelet transforms are applied on the images before compression, from the compressed image decompressed image can be retrieved and then the quality of the decompressed images is deliberate with six performance parameters i.e. Compression ratio, Bit per pixel(BPP), Mean Square Error, Peak Signal to Noise Ratio, and examine which technique is better for image compression.

Key Words: ezw, spiht,asdwr,wdr,stw

I. INTRODUCTION

The multimedia carrier like graphics, audio and video requires large storage capacity and transmission bandwidth. Image compression deals with the problem of reducing the amount of data required to represent an image. Image compression enables the compact representation of an image, thereby reducing the image storage/transmission requirements. With the advancement in multimedia and internet applications, the demands/requirements of the new technologies used grew and developed. To fulfill these demands/requirements in the area of image compression, various efficient and reliable techniques have been formulated / developed. As we know that technology is constantly growing, the sizes and the pixel density of these images are getting enhanced. Hence, efficient techniques are required to maintain their size and reusability. For example, in the field of medicine, highly detailed images require storage of large quantities of digitized clinical data. Due to the bandwidth and storage limitations, these medical images must be compressed before transmission and storage. Diagnosis is effective only when compression techniques preserve all the relevant and important image information needed. Hence, image compression comes into the spotlight. The objective of compression is to reduce irrelevance and redundancy of the image data in order to be able to store or transmit data in an efficient form [1]. The recent growth of data intensive multimedia-based web applications have not only sustained the need for more efficient ways to encode signals and images but have made compression of such signals central to storage and communication technology.

II. IMAGE COMPRESSION OVERVIEW

Nowadays, multimedia computing is becoming a major area of research. There are major reasons why multimedia signals require data to be compressed. Major reasons are large storage of data, slow storage, which does not allow access the data in real time specially video and finally bandwidth, which does not allow video data transmission, which are real time. Compression is achieved by the removal of one or more of three basic data redundancies:

- Coding Redundancy, which is present when less than optimal (i.e. the smallest length) code words are used.
- Inter-pixel Redundancy, which results from correlations between the pixels of an image.
- Psycho Visual Redundancy which is due to data that is ignored by the human visual system (i.e. visually nonessential information).

III. COMPRESSION PRINCIPLES

Number of bits required to represent the information in an image can be minimized by removing the redundancy present in it. There are three types of redundancies:

(i) Spatial redundancy, which is due to the correlation or dependence between neighboring pixel values.
(ii) Spectral redundancy, which is due to the correlation between different color planes or spectral bands.
(iii) Temporal redundancy, which is present because of correlation between different frames in images. Image compression research aims to reduce the number of bits required to represent an image by removing the spatial and spectral redundancies as much as possible.

IV. INTRODUCTION TO WAVELET

Wavelets are functions defined over a finite interval and having an average value of zero. The basic principle of the wavelet is to represent any arbitrary function f *(t)* as a superposition of a set of such wavelets or basis functions. These basis functions (baby wavelets) are obtained from a single prototype wavelet known as the mother wavelet, by dilations or contractions (scaling) and translations (shifts) [36].

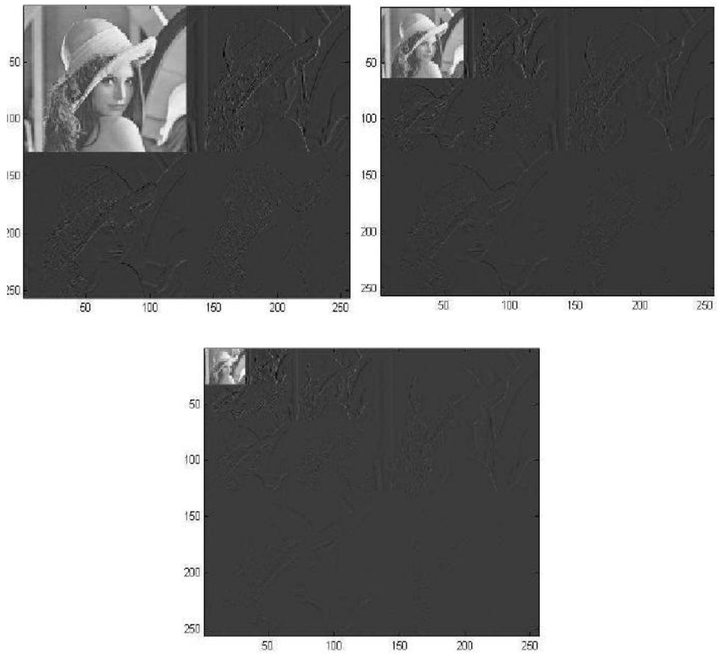

Figure 1: Image Decomposition (a) First Level (b) second level (c) Third Level.

The DWT of a finite length signal *x (n)* having *N* components, for example, is expressed by an *N* x *N* matrix. Wavelets are mathematical functions that were developed by scientists (Engineers) working in various fields for the purpose of sorting data by frequency. Translated data can then be sorted at a resolution which matches its scale. Studying data at different levels allows for the development of a more complete picture.

Both small features and large features are discernable because they are studied separately. Unlike the Discrete Cosine Transform, the wavelet transform is not fourier based and therefore wavelets do a better job of handling discontinuities in data. The HAAR wavelet operates on data by calculating the sums and differences of adjacent elements [37]. The HAAR wavelet operates first on adjacent horizontal elements and then on adjacent vertical elements. The HAAR transform is computed using:

$$\frac{1}{\sqrt{2}}\begin{bmatrix}1 & 1\\1 & 1\end{bmatrix}$$

One nice feature of the HAAR wavelet transform is that the transform is equal to its inverse. As each transform is computed the energy in the data in relocated to the top left hand corner; i.e. after each transform is performed the size of the square which contains the most important information is reduced by a factor of 4.

V. NEED OF WAVELET BASED COMPRESSION

Regardless of the simplicity, satisfactory performance and availability of special purpose hardware for implementation of JPEG compression schemes based on DCT, these are not without their shortcomings.

Since the input image needs to be ``blocked," correlation across the block boundaries is not eliminated. This results in noticeable and annoying ``blocking artifacts" particularly at low bit rates. Lapped Orthogonal Transforms (LOT) attempt to solve this problem by using smoothly overlapping blocks. Although blocking effects are reduced in LOT compressed images, increased computational complexity of such algorithms do not justify wide replacement of DCT by LOT. Therefore scientists go for wavelet based compression.

VI. WAVELET BASED IMAGE COMPRESSION

Wavelet based image compression has achieve much popularity because of their overlapping nature which reduces the blocking artifacts and multi-resolution character, results the high quality reconstructed images. Wavelet based techniques provides significant improvements in picture quality at higher compression ratios. Also, at higher compression ratios, wavelet coding methods degrade much more gracefully than the DCT method.

Wavelet based compression techniques allow the integration of various compression methods into one and hence, a compression ratio of up to 300:1 is achievable. Various novel and classy wavelet based techniques for image compression have been developed and implemented over the past few years. These include Embedded Zero Tree Wavelet (EZW), Set-Partitioning in Hierarchical Trees (SPIHT), Wavelet Difference Reduction (WDR) and Adaptively Scanned Wavelet Difference Reduction (ASWDR) etc.

(a) Embedded Zero-tree Wavelet (EZW) algorithm

The EZW algorithm was one of the first algorithms to show the full power of wavelet based image compression. The EZW algorithm for image compression is a simple and effective algorithm introduced by Shapiro in his paper "Embedded Image Coding using Zero-trees of Wavelet Coefficients" in 1993.An embedded coding is a process of encoding the transform magnitudes that allows for progressive transmission of the compressed image. zero trees are a concept that allows for a concise encoding of the positions of significant values that result during the embedded coding process [40-41].

(b) Set partitioning in hierarchical trees (SPIHT) algorithm

The spiht coding is a highly refined version of the ezw coding. it was introduced by said and pearlman and gives best result i.e highest psnr values for given compression ratios for a wide variety of images. it is probably the most widely used wavelet based image compression algorithm. the term hierarchical trees refers to the quad-trees that we defined in our discussion of ezw. set partitioning refers to the way these quad-trees divide up, partition, and the wavelet transform values at a given threshold [42]. by a careful analysis of this partitioning of transform values, said and pearlman were able to greatly improve the ezw algorithm, significantly increasing its compressive power.

(c) Wavelet difference reduction (WDR) algorithm

A major disadvantage of spiht algorithm is that it only implicitly locates the position of significant coefficients. this makes it difficult to perform operations, such as region selection on compressed data, which depend on the exact position of significant transform values. by region selection, also known as region of interest (roi), we mean selecting a portion of a compressed image which requires increased resolution. this can occur, for example, with a portion of a low resolution medical image that has been sent at a low bpp (bit per pixel) rate in order to arrive quickly [43]. such compressed data operations are possible with the wavelet difference reduction (wdr) algorithm of tian and wells.
the term difference reduction refers to the way in which wdr encodes the locations of significant wavelet transform values, which we shall describe below. although wdr will not typically produce higher psnr values than spiht, we shall see that wdr can produce perceptually superior images, especially at high compression ratios. the only difference between wdr and the bit-plane encoding described above is in the significance pass. in wdr, the output from the significance pass consists of the signs of significant values along with sequences of bits which concisely describe the precise locations of significant values.

(d) Adaptively scanned wavelet difference reduction (ASWDR) algorithm

One of the most recent image compression algorithms is the adaptively scanned wavelet difference reduction algorithm of walker. the adjective adaptively scanned refers to the fact that this algorithm modifies the scanning order used by wdr in order to achieve better performance. aswdr adapts the scanning order so as to predict locations of new significant values. if a prediction is correct, then the output specifying that location will just be the sign of the new significant value the reduced binary expansion of the number of steps will be empty. therefore a good prediction scheme will significantly reduce the coding output of wdr. the prediction method used by aswdr is the following: if w(m) is significant for threshold t, then the values of the children of m are predicted to be significant for half-threshold t=2. for many natural images, this prediction method is a reasonably good one. the scanning order of aswdr dynamically adapts to the locations of edge details in an image, and this enhances the resolution of these edges in aswdr compressed images

VII. RESULTS

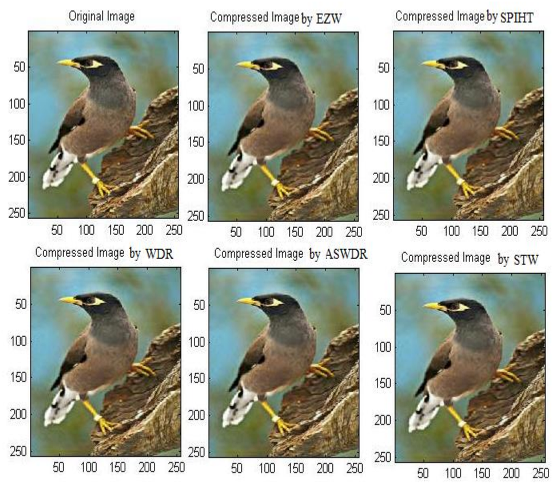

Table 6.1: Performance Metrics of Type 1 Orthogonal Wavelet (HAAR)

Methods	Performance Metrics			
	CR	PSNR	MSE	BPP
EZW	28.5787	42.4225	3.7225	6.8589
STW	17.0156	38.1420	9.9742	4.0837
SPIHT	10.8159	36.747	13.7522	2.5958
WDR	33.0683	42.4225	3.7225	7.9364
ASWDR	31.9626	42.4225	3.7225	7.6710

VIII. CONCLUSION

We have implemented and tested the quality assessment of image compression with various algorithms of wavelet ransform. With Bior1.1 wavelet family, EZW, WDR and ASWDR perform well in terms of quality of images (PSNR) whereas the WDR gives the better compression ratio (CR). Similarly in Bior5.5 wavelet family, STW give the better quality of images whereas WDR gives the better compression ratio (CR).

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