



Image Compression Based on Improved Embedded Zero Wavelet Approach

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Abstract: *Nowadays, there has been huge innovations and developments in the research areas of image compression techniques. Mainly, the innovations in image compression is mainly contributed to the need of efficient storage techniques and data transmission among the individuals. In order to obtain maximum storage and high transmission capabilities, various compression algorithms should be employed and compared in order to find the best optimal technique for image compression. The image compression technique has applied in various diverse fields such as medical imaging, videophones, high definition television and other multimedia applications. Another major field where image compression technique applied is browsing, where the key focus is to get high compression. Previously, the wavelets are used and it appears as the most useful technique for image compression. Now, in this paper, various image compression techniques based upon wavelets are compared. The effects of image contents and its corresponding compression ratios, filter orders of various wavelet functions and number of decompositions are observed. The outcomes of the image compression techniques such as Wavelet Difference Reduction (WDR), Set Partitioning In Hierarchical Tree (SPIHT), Embedded Zero Wavelet (EZW), Adaptively Scanned Wavelet Difference Reduction (ASWDR), Spatial Orientation-tree Wavelet (STW) were compared and tabulated by using the various parameters such as Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR) and (Bits Per Pixel) BPP values from the image which was reconstructed. In this paper, an Improved Embedded Zero Wavelet (IEW) is proposed and compared with other image compression techniques.*

Keywords: *Improved Embedded Zero Wavelet.*

I. INTRODUCTION

In order to process, transmit and store the large amounts of images, the effective image compression technique must be needed. Reducing the size of the image file or simple compression is not adequate for many applications. Some other scalable and embedded properties are required too. Recently, over the last decade, Discrete Wavelet Transform (DWT) has become one of the most important and useful tools in image analysis and coding which provides an effective multi resolution image representation [7]. Many showed interest to study Wavelet transforms over the last decade. In transform based EEG compression, Higgins [11] defined the effects of wavelet coefficient quantization. Li [12] presented and addressed the energy aggregation and correlated features of image wavelet coefficient in Improved Wavelet Lossless Compression Algorithm (IWLCA). Currently, the best effective solution is to compress the multimedia data before its transmission and storage. At the receiver end, once again decompress the data for playback. The basic aim of image compression is to reduce the bit rate for storing or transmitting the multimedia data while maintaining an adequate fidelity or image. The wavelet methods have many successful applications. Among the successful one, we used the transform-based image compression technique (also called coding). The substantial improvements in picture quality can be provided by wavelet-based coding at reasonable and higher compression ratios [4]. Over the past few years, various types of wavelet based image compression algorithms have been innovated and implemented such as Set-Partitioning in Hierarchical Trees (SPIHT) [3], Adaptively Scanned Wavelet Difference Reduction (ASWDR) [1], Embedded Zero Tree Wavelet (EZW) [2],[13],[14] Wavelet Difference Reduction (WDR) [5], and STW [6]. Here an improved version of EZW approach is discussed.

II. AIMS AND OBJECTIVES

The main and important purpose of this paper is to develop an image compression scheme based upon wavelet with higher compression ratio which can also retain the important information in the image. Here an Improved Embedded Zero Wavelet Compression Scheme is proposed and its performance is compared with other methods.

A. Embedded Zero tree Wavelet (EZW)

Among many algorithms, the EZW algorithm was the first one, to show the full power of wavelet-based image compression. It was developed by Shapiro [2]. An encoder named EZW encoder is specially designed to use with wavelet transforms. Based upon the progressive encoding, the EZW encoder compress an image into a bit stream with

highly increasing accuracy. The EZW encoder has two important results. First, in general, the natural images have a low pass spectrum. When the wavelet transform technique is applied on the image, the energy in the sub bands decreases as the scale decreases (high scale means low resolution and low scale means high resolution). Therefore, on average, the higher sub bands will have the smaller wavelet coefficients compared to the lower sub bands. These results show that the progressive encoding is the natural choice for compressing the wavelet transformed images, where the higher sub bands add only the details. Secondly, the large wavelet coefficients are more important compared to small wavelet coefficients. In several passes, these two observations are exploited by encoding the wavelet coefficients in decreasing order. EZW algorithm employs progressive and embedded transmission and it uses zero tree concepts. The tree is coded with a single symbol and uses a predefined scanning order. It provides the best results without pre-stored tables, training and code-books. But, in EZW algorithm, the transmission of coefficient position is missing and therefore, no real compression take place.

B. Set Partitioning in Hierarchical Trees (SPIHT)

SPIHT is an image compression coder which works based upon the principle of wavelet. First, the wavelet transforms are extracted from the image and then it transmits information about the wavelet coefficients. To reconstruct the wavelet, the decoder uses the received signal. Finally, it performs an inverse transform from the reconstructed wavelet to recover the image. In still image compression, SPIHT and EZW coder are significant breakthroughs in which they provided highly improved and significant quality over vector quantization. While not requiring training, Joint Photographic Expert Group (JPEG), and wavelets combined with quantization, produces an embedded bit stream. SPIHT algorithm displays exceptional characteristics over several properties [8]. It provides high image quality with a high rate of PSNR. It is the fast encoding and decoding scheme. It can be used for lossless compression because it is a fully progressive bit-stream and it can also be combined with error protection.

Discrete Wavelet Transform (DWT) runs a low-pass and high-pass filter over the single dimension signal. The outcome is a new image which comprises of a high and low-pass sub band. From the already achieved previous level, the next level of the wavelet is calculated by repeating the vertical and horizontal transformations on the low-pass sub band. Therefore, many levels are required. For all the levels, the DWT procedure is repeated. The procedure is fully reversible for each time (within the limits of fixed precision). Hence, from the wavelet transformed image, the original image can be reconstructed. SPIHT is a method of coding and decoding [9]. SPIHT implicitly locates the position of significant coefficients and also more memory required due to the usage of lists.

C. Wavelet Difference Reduction (WDR)

The primary problem with SPIHT is that it only locates the position of significant coefficients implicitly. This makes it very difficult to perform operations which rely upon the position of significant transform values, such as region selection on compressed data. Region selection, which is also known as Region Of Interest (ROI), means a portion of a compressed image that requires increased resolution.

The one and only difference between WDR and bit-plane encoding is the significant pass. In WDR, the final outcome from the significance pass consists of the signs of significant values along with bits sequences. Finally, it concisely describes the precise locations of significant values [1]. Compared to SPIHT this approach provide better perceptual image quality and preserve edge. There is no search through quad trees and hence it is less complex. But, PSNR of WDR is low compared to SPIHT.

D. Adaptively Scanned Wavelet Difference Reduction (ASWDR)

The ASWDR algorithm aims to improve the subjective perceptual qualities and the objective distortion measures of compressed images. PSNR is a commonly used term to measure the error, while edge correlation measure is used in quantifying the preservation of edge details in the compressed images, and it seems to perform well to subjective impressions of the perceptual quality of the compressed images [1]. Usually, high compression images are used in reconnaissance and in medical applications in which fast transmission, ROI and multi-resolution detection are employed. Usually, PSNR values for ASWDR is higher than the PSNR values of WDR. The ROI was allowed in WDR and ASWDR algorithms but not in SPIHT. Therefore, it facilitates multi-resolution detection by displaying edge details at low bit rates. ASWDR dynamically adapts to the locations of edge details because it uses modified scanning order. It encodes more significant values than WDR and predicts the exact locations of new significant values.

E. Spatial-orientation Tree Wavelet (STW)

STW is an essential component for the SPIHT algorithm. The primary difference is that SPIHT is slightly more careful in organizing its coding output. STW uses a different approach to encode the zero tree information and this seems to be the only difference between STW and EZW. Usually, STW uses a state transition model. The locations of transform values undergo state transitions from one threshold to the next. This model allows STW to reduce the number of bits needed for encoding. In order to mark the locations, EZW uses the code for the symbols R and I output, whereas the STW algorithm uses states IR, IV, SR, and SV and the outputs code for state-transitions such as IR \rightarrow IV, SR \rightarrow SV, etc.

III. MATERIALS AND METHODS

After encoding, the compression program obtains three different types of information: data about the wavelet coefficient of quantization, information about the positive/negative sign, and relative location information which

are used to reconstruct original image. Hence, PSNR and CR of compressed image can be evaluated. Comparing with EZW, because it exploits hierarchical zero-tree structure, the symbol information contained POS, NEG, IZ, and ZTR and refinement information is needed. IEZW scheme which is equivalent to original EZW can be defined as follows:

A. Improved Embedded Zero-tree Wavelet Compression

1. Initial conditions
 - (a) Initial state of threshold, $T = 2^E$, where $E = \lceil \lg \max(c_{ij}) \rceil$, where c_{ij} represents the wavelet coefficients, and i, j represents the row number and column number in the image.
 - (b) Number of bit-plane, which is used in the progressive transmission.
2. Wavelet transform via lifting wavelet transform is used.
3. Set a threshold T . In each iteration, set $T = T/2$.
4. Encode wavelet coefficient c_{ij} as follows:

POS, if $c_{ij} \geq T$ then $c_{ij} = c_{ij} - T$; where c_{ij} is a significant coefficient and $c_{ij} \geq 0$.

NEG, if $c_{ij} \geq T$ then $c_{ij} = c_{ij} + T$; where c_{ij} is a significant coefficient and $c_{ij} < 0$.

IZ, if $c_{ij} < T$, and there exists descendant of c_{ij} whose value is greater than T (i.e., c_{ij} is an isolated zero tree).

ZTR, if $T \geq 1$, go to step 3, else terminate encoding.

Finally. After the completion of encoding procedure, the compression program obtains the symbol information. Then refinement is done to reconstruct the image which is close to the original image.

B. Results and Discussions

Table1 PSNR, MSE AND BPP OF VARIOUS METHODS

	EZW	SPIHT	STW	WDR	ASWDR	IEZW
MSE	0.08782	8.431	1.152	6.27	6.27	0.07
	0.6868	7.597	1.668	4.785	4.875	0.61
	0.415	6.651	1.445	4.492	4.492	0.38
	0.1068	5.485	1.853	3.378	3.378	0.08
PSNR	58.69	38.87	47.52	41.33	40.16	59.21
	59.76	39.32	45.91	39.38	41.33	60.83
	51.95	39.1	46.53	41.61	41.61	52.88
	57.85	40.74	45.45	42.84	42.84	59.13
BPP	6.5267	3.737	4.3497	6.4012	6.0975	6.45
	7.1232	3.8028	4.684	7.131	6.7708	7.08
	4.6458	3.1327	3.3497	5.3781	5.0306	4.52
	5.9339	2.8585	3.0191	4.9598	4.7419	5.47

Table 1 shows the PSNR, MSE, BPP of various methods. PSNR of IEZW method is higher than all other methods. And also MSE of IEZW method is lower than the other methods. The BPP value is very closer to WDR and ASWDR. BPP of SPIHT method is lower than other methods but the PSNR value is low than all other method and MSE is higher than all other method. STW has the lower MSE value except EEZW but it PSNR and BPP values are moderate. The WDR and ASWDR methods have better MSE than SPIHT but compared to EEZW and STW it did not perform well. The overall performance of IEZW is good compared to all methods.

The Figure 1 represents the overall performance for various method. Among the five methods, EZW performs better than other methods here. MSE of EZW method achieves lower value and peak signal to noise ratio achieves higher value compared to other methods.

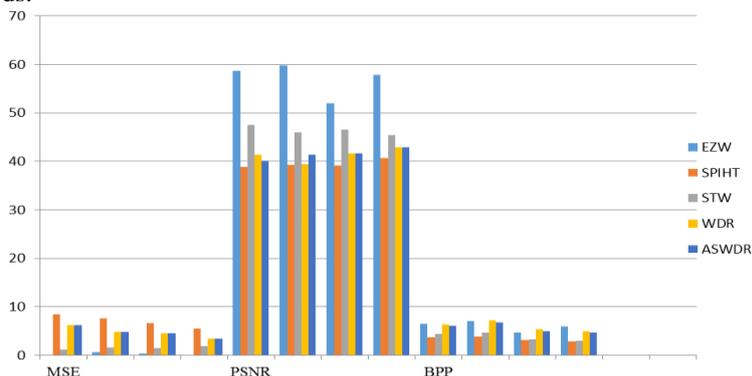


Fig.1. Comparison of MSE, PSNR and BPP

The different types of parameters such as compression ratio, Peak signal to noise ratio and Bit per pixel have been employed and obtained the final results by comparing the average performance of various methods which was depicted in Table 2.

Table 2 AVERAGE PERFORMANCE OF DIFFERENT METHODS

	EZW	SPIHT	STW	WDR	ASWDR	IEZW
CR	75.715	42.29075	48.1325	74.597	70.7525	76.56
PSNR	57.0625	39.5075	41.29	41.485	41.485	59.24
BPP	6.0574	3.38275	3.850625	5.963	5.6602	5.92
MSE	4.73125	4.73125	0.3241	7.041	1.5295	3.84

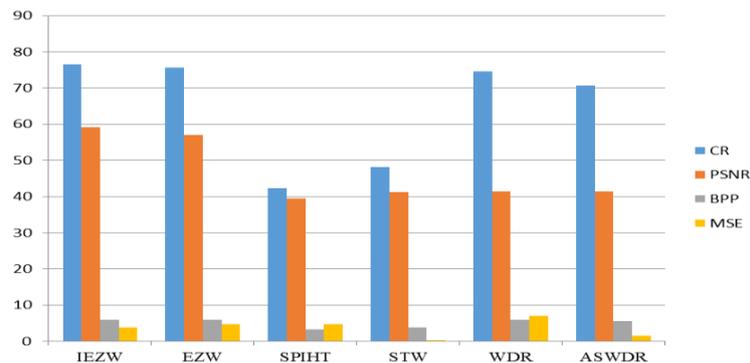


Fig.2. Average Performance of Different methods

Figure 2 illustrate the graphical representation of CR, PSNR, BPP and MSE value of different methods. It is inferred that CR and PSNR of IEZW method is higher than all methods while maintaining moderate error rate.

IV. CONCLUSION

In this work, a comparative analysis of different wavelet based image compression method has been done. Experiments showed that IEZW approach achieves the best compression ratio compared with EZW, STW, WDR, ASWDR and SPIHT method. A modified approach of IEZW can be done to improve the compression ratio more while retaining the image quality and error.

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