Enhancement of Compression Ratio and Image Quality using ISPIHT with MFHWT

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ABSTRACT
This paper presents a new approach for compression of medical images with MFHWT (Modified Fast Haar Wavelet Transform) and SPIHT (Set Partitioning In Hierarchical Trees). It provide high compression ratio with high picture quality. The Modified Fast Haar Wavelet Transform is used to decompose the image at different frequency levels. It has high multi-resolution characteristics. The CR (compression ratio) of proposed method is better than existing method (SPIHT). Medical images have a number of regions where intensity is changing slowly or even have a constant value. Such regions are compressed with higher compression ratio. In medical applications image distortion is not acceptable. So the quality of the images is also improved in proposed method in terms of PSNR (Peak Signal to Noise Ratio).

Keywords
Compression Ratio, Haar Wavelet Transform (HWT), Image Quality, Modified Fast Haar wavelet transform, PSNR, SPIHT.

1. INTRODUCTION
Image compression is a fast paced and dynamically changing field with many different types of compression methods. Images contain large amount of data hidden in them, which is highly correlated. Image compression plays a vital role in several important and diverse applications, including televideo conferencing, remote sensing, medical imaging [1], [4], magnetic resonance imaging [5] and many more [2]. These require fast transmission and large space to store data. These requirements are not fulfilled with old techniques of compression like Fourier Transform, Hadamard and Cosine Transform etc. due to large mean square error occurring between original and reconstructed images. Wavelet transform or wavelet analysis is a recently developed mathematical tool for signal analysis. It is very efficient approach. The Haar Transform technique is widely used these days in wavelet analysis. SPIHT is the wavelet based image compression method. It provides the highest image quality, progressive image transmission, fully embedded coded file, simple quantization algorithm, fast coding/decoding, completely adaptive, lossless compression, and exact bit rate coding and error protection.

2. HAAR TRANSFORM AND FAST HAAR TRANSFORM
Haar wavelet is the simplest wavelet. As we knew that wavelet is the best method of compression. Haar transform or Haar wavelet transform has been used as an earliest example for orthonormal wavelet transform with compact support. The haar transform (HT) is one of the simplest and basic transformations from a space domain are a local frequency domain. This method reduces the calculation work [11]. HT decomposes each signal into two components. One is called average (approximation) and other is known as difference (detail). The Haar wavelet's mother wavelet function $\varphi(t)$ can be described as:

$$\varphi(t)\begin{cases} 1 & 0 \le t \le 1/2 \\ -1 & 1/2 \le t \le 1 \\ 0 & otherwise \end{cases} \qquad (1)$$

This is also called mother wavelet. In order to perform wavelet transform, Haar wavelet uses translations and dilations of the function, i.e. the transform make use of following function:

$$\varphi_{a,b}(t) = \frac{1}{\sqrt{a}}\varphi\left(\frac{t-b}{a}\right) \; ; a, b \in R^1 \text{ and } a \neq 0 \qquad (2)$$

Its scaling function $\emptyset(t)$ can be described as

$$\emptyset(t) = \begin{cases} 1 & 0 \le t < 1, \\ 0 & otherwise. \end{cases} \qquad (3)$$

In Haar transform, basically, 2^n data (or we refer as nodes) has been used at n level. By taking average and difference from two nodes from previous level, approximate coefficients and detail coefficients for next level, n −1, n − 2, n − 3 of decomposition nodes are counted. The process is called FHT (Fast Haar Transform). The results indicated Haar is the best for signals with step or block function and Haar is the best method for Signal compression [13].

3. MODIFIED FAST HAAR WAVELET TRANSFORM
For Modified Fast Haar Transform, MFHT, it can be done by just taking (w+ x + y + z)/ 4 instead of (x + y)/ 2 for approximation and (w+ x − y − z)/ 4 instead of (x − y)/ 2 for differencing process. Here 4 nodes have been considered at once time [10]. Notice that the calculation for (w+ x − y − z)/ 4 will yield the detail coefficients in the level of n − 2. A significant improvement with MFHT is that the number of approximate coefficients as well as the number of division operation can be reduced.

4. SPIHT ALGORITHM
The algorithm of set partitioning in hierarchical tree is called as SPIHT algorithm, which is improved by the EZW coding. SPIHT represents that it provides lower costs with respect to compression complexity and prediction, as proposed in JPEG and JPEG 2000, to achieve higher compression performances [13]. In the SPIHT algorithm, the image is first decomposed into a number of sub bands by means of hierarchical wavelet

decomposition [3]. The sub bands obtained for two-level decomposition are shown in Fig. 1.

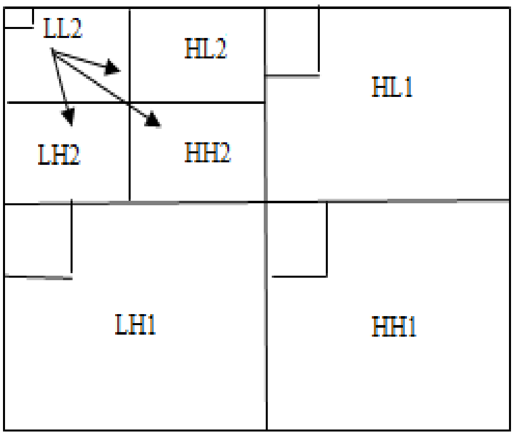


Fig.1 Two level wavelet decomposition and spatial orientation tree

The sub band coefficients are then grouped into sets known as spatial-orientation trees, which efficiently exploit the correlation between the frequency bands. The coefficients in each spatial orientation tree are then progressively coded from the most significant bit-planes (MSB) to the least significant bit-planes (LSB), starting with the coefficients with the highest magnitude and at the lowest pyramid levels.

5. PROPOSED ALGORITHM

In this current research we are combining the MFHWT with SPIHT to obtain the better compression without losing much information. The proposed algorithm can be implemented to test a set of different natural medical and grey scale images. There are following steps to perform the operation of compression with improved spiht:

Step1. Read the image as a matrix.

Step2. Apply MFHWT, along row and column wise on entire matrix of the image.

Step3.Computes the approximation coefficients matrix and details coefficients matrices obtained by wavelet decomposition MFHWT of the input matrix. First average sub signal (a' =a1, a2, $a_{n/2}$), at one level for a signal of length N i.e. f = (f1, f2, f3, f4… f_n) and first detail sub signal (d'= d_1, d2, d3….d_n)

Step4.Applying Singular value decomposition on approximation coefficients matrix.

Step5. After applying MFHWT we get a transformed image matrix of one level of input image.

Step6. For reconstruction process, applying the inverse.

Step7.Calculate Compression ratio, BPP and PSNR for reconstructed image.

The SPIHT method is not a simple extension of traditional methods for image compression. The method deserves special attention because it provides highest image quality. In proposed work spiht is used with modified fast haar wavelet for the decomposition of an image. The results are analyzed in terms of compression ratio (CR) and Peak signal-to-noise ratio (PSNR).Compression ratio is defined as the ratio of an original image and compressed image.

$$\text{compression ratio} = \frac{\text{original image size}}{\text{compressed image size}} \qquad (4)$$

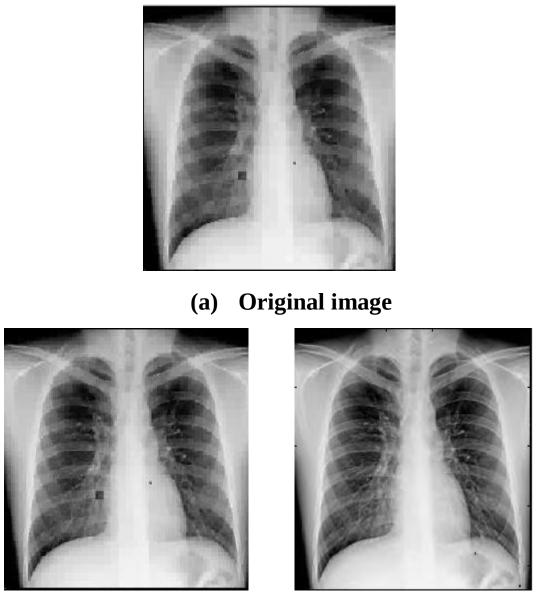
Peak signal-to-noise ratio (PSNR) is one of the quantitative measures for image quality. The MSE for N x M size image is given by:

$$\text{MSE} = \frac{1}{MN}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\|I(i,j) - K(i,j)\| \qquad (5)$$

Medical images have a number of regions where intensity is changing slowly or even have a constant value. Such regions are compressed with higher compression ratio. In medical applications image distortion is not acceptable [6]. So, the quality of the images also improved in proposed method in terms of PSNR.

6. RESULTS AND CONCLUSION

The image compression has been implemented using MATLAB version (R2009a). Image compression using the Modified Fast Haar Wavelet method with SPIHT seems to be very powerful for the medical images. As far as the quality of medical images is concerned, there is lot of information that need to be maintained to diagnose the disease. With compression this may be lost. For example, the DCT was used for the JPEG format to compress images; with wavelet the performance can be seen to be far superior. This is because the wavelet analysis is done on the entire image rather than sections at a time. Changing the decomposition level changes the amount of detail in the decomposition. Thus, at higher decomposition levels, higher compression rates can be gained. This method is tested on different medical images like chest, spinal cord and knee. The results are compared on the basis of CR, BPP (Bits per Pixel), and PSNR.



(a) Original image

(b)SPIHT compression **(c) ISPIHT compression**

Fig.2: Images of Chest

(a) original image

(b) SPIHT compression **(c) ISPIHT compression**

Fig.3: Images of Spinal Cord

(a) original image

(b) SPIHT compression **(c) ISPIHT compression**

Fig.4: Images of Knee

The original, SPIHT compressed and ISPIHT compressed images of chest, spinal cord and knee are shown in figures1, 2 and 3 respectively. It is clear from these figures that the proposed method improves the image quality.

Table 1: Compression ratio, BPP and PSNR values attained By Proposed and Existing method

Medical images	SPIHT			Improved SPIHT (MHWT + SPIHT)		
	PSNR	**CR**	**BPP**	**PSNR**	**CR**	**BPP**
Chest	61.25	2.01	0.48	65.01	6.62	1.59
Spinal cord	55.10	1.81	0.43	60.66	5.36	1.28
Knee	62.13	7.68	1.82	66.32	23	5.75

The difference between the existing method and proposed method in terms of various parameters like PSNR, CR and BPP for the medical images like chest, spinal cord and knee is shown in table 1. It is observed that the values of PSNR, CR and BPP increase with the use of ISPIHT for all medical images under test.

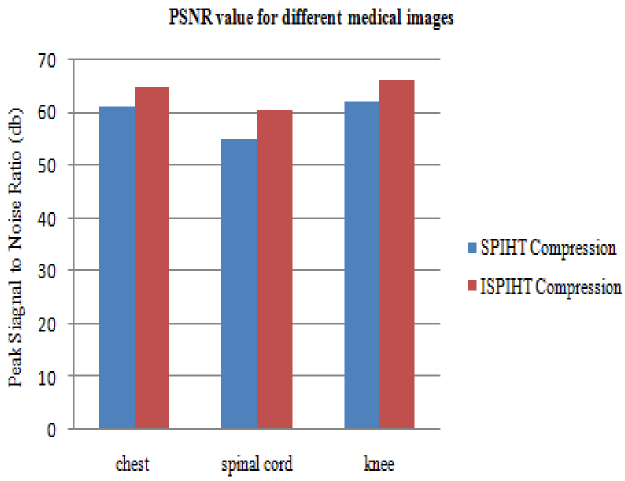


Fig.5 PSNR attained for test images.

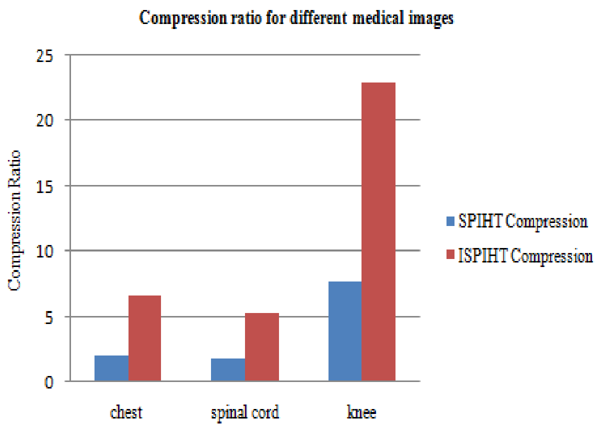


Fig.6 Compression ratio attained for test images.

The comparison of the compression ratios and PSNR of proposed method i.e. ISPIHT and the existing SPIHT algorithm with the aid of histograms for the test medical images of chest, spinal cord and knee is shown in figure 5 and figure 6. There is a consistent improvement of compression ratio and PSNR for the different images.

7. CONCLUSION

The compression ratio of proposed method is better than existing method. Spiht method degrades image quality at lower bit rate. It does not preserve the high frequency details like edges, corners etc. The Proposed method highly preserves quality of images with high Compression Ratio and Bits per pixel. The quality of the image is also improved in terms of PSNR. The edges are the important parameters in consideration of the peak signal to noise ratio values. The proposed method can also be extended for the analysis of other features of the image. It can also be used to compress the image that is used in the web applications.

8. REFERENCES

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