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Medical Image Compression Using Improved SPIHT and MFHWT

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Abstract- Set Partioning in Hierarchical Trees (SPIHT) algorithm is a significant improvement of Embedded Zero Tree Wavelet (EZW) algoritm. It is based on the zero tree structure of EZW algorithm uses the smallest mean square error criterion.The most important wavelet coefficients are first encoded. It has got a good compression performance. The work is particularly targeted towards wavelet image compression using haar transformation with an idea to minimize the computational requirements by applying different compression thresholds for the wavelet coefficients. These results are obtainted in the fraction of seconds. It improves the quality of the reconstructed image with high PSNR values as well as preserves the significant image details.

Index Terms—Haar Wavelet Transform, Image Quality, Mean Square Error (MSE), Modified Fast Haar Wavelet Transform, PSNR, SPIHT

1 Introduction

Compression of medical images to reduce their storage and transmission bandwidth requirements is of great interest in medical image processing. However, the compression will reduce the image fidelity, especially when the images are compressed at lower bit rates. The constructed image suffers from blocking artefacts. The quality of the image is severly degraded under the circumstances of high compression ratio, which is shown bye the JPEG standard. In the recent years, much of the research activities in image coding have been focused on the discrete wavelet transform (DWT) as the overlapping nature of the transform alleviaties blocking artefacts. The multi-resolution character of the wavelet decomposition leads to superior energy compaction and perceptual quality of the decompressed image. Furthermore, the multi-resolution transform domain means that wavelet compression methods degrade much more gracefully than block-DCT methods as the compression ratio increases. Now a day's discrete wavele transform is used for the decomposition and reconstruction of images [1, 2].

Wavelet based compression provides multi-resoluion hierarchical characteristics. Hence an image can be compressed at different levels of resolution and can be sequentially processed from low resolution to high resolution. Wavelets are localized in both time (space) and frequency (scale) domains. Hence, it is easy to capture local features in a signal.

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2. Haar Transform and Fast Haar Transform

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 [3]. HT decomposes each signal into two components, one is called average (approximation) and other is known as difference (detail). Haar transform is real and orthogonal. The basic vectors of haar matrix are sequence ordered. It bears various properties like orthogonality, linear phase, compact support, perfect reconstruction.

3. Modified Fast Haar wavelet Transform

For modified fast haar wavelet transform (MFHWT) it can be done by just taking (w+x+y+z)/4 instead of taking (x+y)/2 for approximation and (w+x-y-z)/4 instead of (x-y)/2 for differencing process. 4 nodes have been considered at once time. Notice that the calculation for (w+x-y-z)/4 will yield the detail coefficients in the level of n-2. For the purpose of getting detail coefficients, differencing process (x-y)/2 still need to be done. The decompostion step can be done by using matrix formulation as well to reduce the memory requirements of the transformand the amount of inefficient movement of haar coefficients. The drawback in number of addition and subtraction operation can be balanced by the decreasing in number of division operation [4].

Overall, the algorithm of decomposition for the MFHWT for 2N data as follows:

For coefficients at level $N-\theta$, where 1, int () 2

$N\theta$ = 4

$x4i + x4i+1 + x4i+2 + x4i+3$, Where i 0, (2N) 4=1

(Approxinate coefficients), 4

$x4i + x4i+1 - x4i+2 - x4i+3$, Where i 0, (2N) 4=1

(Detail coefficients at level n-2), 2

$x2i - x2i+1$, Where i 0 (2N) 2 = 1

(Detail coefficients at level n-1).

If the 2N is divisible by 4, the decomposition steps can be reduced by applying the algorithm. All the necessary coefficients can be obtained. If the 2N is divisible by 2only, we need to conduct the last decomposition step by using the similar way as for FHT. The comparison between typical Fast Haar Transforms, FHT and proposed Modified Fast Haar Transform, for N=4.

4. Image Compression

Image compression can be lossy or lossless. Lossless compression is sometimes preferred for artificial images such as technical drawings, icons or comics. This is because lossy compression methods, especially when used at low bit rates, introduce compression artifacts. Lossless compression methods may also be preferred for high value content, such as medical imagery or image scans made for archival purposes.

4.1 Set Partioning in Hiersrchichal Trees (SPIHT)

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, Exact bit rate coding and Error protection[4][5]. SPIHT makes use of three lists – the List of Significant Pixels (LSP), List of Insignificant Pixels (LIP) and List of Insignificant Sets (LIS). These are coefficient location lists that contain their coordinates. After the initialization, the algorithm takes two stages for each level of threshold. One is the sorting pass in which lists are organised. The other is the refinement pass which does the actual progressive coding transmission. It is capable of recovering the image perfectly by coding all bits of the transform. However, the wavelet transform yields perfect reconstruction only if its numbers are stored as infinite imprecision numbers. The block diagram showing compression using DWT and ISPIHT is given in figure 1.

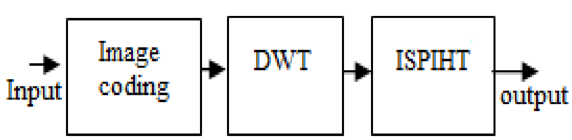


Fig.1 Compression using DWT and ISPIHT

5. PROPOSED ALGORITHM

Wavelet transform, due to its time frequency characteristics, has been a popular multiresolution analysis tool. Its discrete version, i.e. DWT has been widely used in various applications. The proposed algorithm has been implemented to test a set of different natural gray scale medical images.

The proposed algorithm is based on SPIHT with MFHWT. The SPIHT method is not a simple extension of traditional methods for image compression, and represents an important advance in the field. The method deserves special attention because it provides highest image quality. In proposed work spiht is used with haar wavelet for the decomposition of an image. It is observed that SPIHT provides better results. It can be used to compress the image that is used in the web applications. MFHWT is very efficient method to decompose the image. it also reduces the calculation work. It is shown in the flow chart given in figure 2.

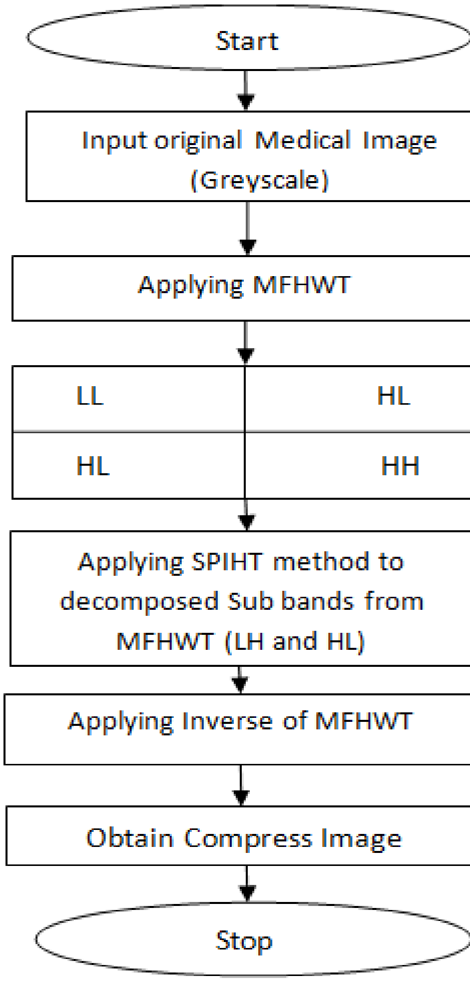


Fig.2 Flow chart of proposed method (ISPIHT)

6. RESULT AND DISCUSSION

The image compression has been implemented using MATLAB version (R2009a). Image compression using the modified Wavelet method with SPIHT seems to be very powerful for the medical images. As far as the quality for medical images is concern, there is lot of information that needs to maintain to diagnose the disease. With compression, it may be lost. Wavelet analysis 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.

The proposed algorithm has been implemented to test a set of different natural gray scale medical images:

Step I: Consider the input medical Image (Grayscale).

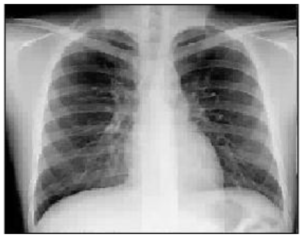
Step II: Decompose the image using wavelet (Sub band) with HWT:

In HWT, first average sub signal (a' =a1,a2, a3… $a_{n/2}$), at one level for a signal of length N i.e. f =(f1, f2,f3,f4…fn) is and first detail sub-signal(d'= $d_1,d_2,d_3\ldots d_n$), at the same level.

Step III: Applying SPIHT to decomposed sub-signal (d'= d_1, d2, d3….d_n),

StepIV: For reconstruction process, applying the inverse and calculate MSE and PSNR for reconstructed image.

The original image and compressed images of chest using SPIHT and ISPIHT are shown in figure 3.



(a) original image

(b) Spiht compression

(c) ispiht compression

Fig.3 Images of chest

The original image and compressed images of chest using SPIHT and ISPIHT are shown in figure 4.

(a) original image

(b) Spiht compression

(c) ispiht compression

Fig.4 Images of spinal cord

The respective values of PSNR for chest and spinal cord for compression with spiht and ispiht are given in below table 1.

TABLE 1
COMPRESSION WITH SPIHT AND ISPIHT

Compression method	Images	PSNR
Spiht	Chest	60.25
Ispiht	Chest	65.15
Spiht	Spinal Cord	55.10
Ispiht	Spinal Cord	60.66

The hisrogram for PSNR for the test images of chest and spinal cord is shown in figure 5

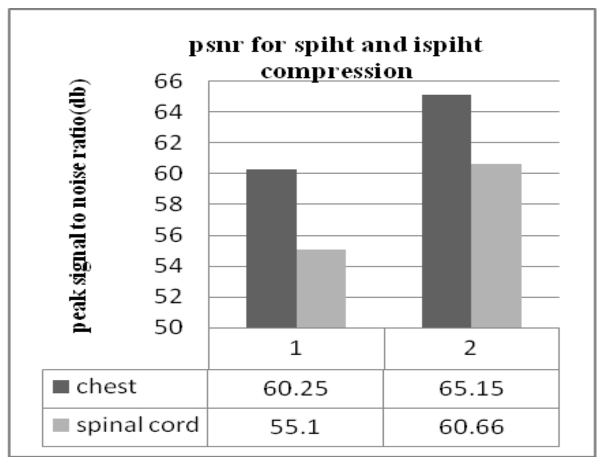


Fig.5 PSNR attainted for test images

It is clear from table 1 and figure 5 that the PSNR value of the compressed images of chest increases to 65.15 with ISPIHT. It was obtainted as 60.25 with SPIHT. Also, it is observed that for the test images of spinal cord the value of PSNR increases to 60.66 with ISPIHT which was observed as 55.10 with SPIHT. This technique not only compressed the images to some extent but aalso maintains the image quality. Hence, it increases the PSNR when SPIHT used with modified HWT.

7. Conclusion

In this paper, the performance in terms of PSNR that obtainted with SPIHT compression technique are compared with ISPIHT (modified fast haar wavelet transform with spiht). The results of the above techniques are compared by using PSNR values form the reconstructed image. These compression algorithms

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provide a better performance in picture quality. One of the important features of SPIHT is that it uses the progressive transmission and embedded coding. It is observed that ISPIHT gives a high PSNR value for the compressed test images i.e of chest and spinal cord in the present paper as compared to thar of the SPIHT technique.

The above technique will be further used to analyse the PSNR of other medical images. Also, the performance of the medical images in terms of other parameters like compression ratio and bit per pixel will be analysed.

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