PERFORMANCE IMPROVEMENT OF SPIHT ALGORITHM USING HYBRID IMAGE COMPRESSION TECHNIQUE

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***ABSTRACT*:** *In modern communicative and network computing, sharing and storing image data effectively are widely used. For sharing, transmitting and storing the image data efficient algorithm can be required to reduce memory requirement, transmission time for fast processing even though, there have been significant development in storage device capacity. To meet the requirement people are trying to Research and find better and better image compression techniques. Wavelet based image compression technique are widely used for their multi resolution characteristics. We have presented various steps involved in the general procedure for compressing images and SPIHT (**Set Partitioning In Hierarchical Tree)** algorithm. We have used DCT and DWT along with SPIHT to improve the performance at low bit rates. Further by using modified SPIHT and Huffman coding compression ratio can be improved.*

Keywords—Compression, DCT, Wavelet Compression, DWT, vector quantization, SPIHT, DCTSPIHT.

1: INTRODUCTION

Image compression is getting more and more attention day by day as high speed compression and good quality of image are in high demand. One advantage of an Image compression is to reduce the time taken for transmission of an image. For example, an image has 512 rows and 512 columns. Without compression, totally 512 x 512 x 8 = 2,097,152 bits data needed to be stored. And, each pixel is represented by 8-bit data format. Now to compress it means to reduce the number of bits needed to store those bits without sacrificing a lot for image quality. The full compression-decompression flow is as shown in Figure.1 Image compression is a problem of reducing the amount of data required to represent a digital image. It is a process intended to yield a compact representation of an image, hereby reducing the image storage/transmission requirement. The reduction in image size allows more images to be stored in given amount of memory space.

The main objective of image compression is to find an image representation in which pixel are less correlated.The two fundamental principles used in image compression are reduncy and irrelevancy. Compression is achieved by removal of one or more of the three basic data redundancies.

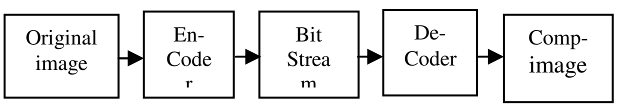

Fig.1 The basic flow of image compression coding

- Coding Redundancy
- Interpixel Redundancy
- Psychovisual Redundancy

A. *Coding redundancy:*

Coding redundancy is used to remove the redundancy present in the information bits. Entropy coding is used to remove such kind of redundancy by assigning code words to the corresponding symbols according to the probability of the symbols. In general, the entropy encoders are used to compress the data by replacing symbols represented by equal-length codes with the codewords whose length is inversely proportional to corresponding probability.

B. *Interpixel redundancy:*

By reducing the correlation between interpxel of an image one can achive the compresion.This is the most important part of the image compression algorithm.

Predictive Coding such as DPCM (Differential Pulse Code Modulation and Orthogonal Transform like Karhunen-Loeve Transform (KLT) and Discrete Cosine Transform (DCT) are the two most well-known transforms are used to for compression. Subband Coding such as Discrete Wavelet Transform (DWT) is also a lossy coding method. The objective of subband coding is to divide the spectrum of one image into the lowpass and the highpass components.

C. *Psychovisual redundancy:*

Psychovisual redundancy is due to data that is ignored by human visual system. By eliminating this kinds of data human eye can not recognise the exclusion of an original image data. To reduce psychovisual redundancy we can use quantizer. This method is loosy Since the elimination of psycovisually redundant data results in a loss of quantitative information. The objective of quantization is to reduce the precision and to achieve higher compression ratio. The shortcoming of quantization is that it is a lossy operation, which will result into loss of precision and unrecoverable distortion.

2: TYPES OF IMAGE COMPRESSION TECHNIQUES

Digital image compression can be divided mainly in two categories: lossless and lossy compression. Lossless compression is used for artificial images. They use low bits rate. There is a possibility of loss some of the data during this process. While lossless compression is preferred in medical images and military images.

A. *Lossy image compression:*

In lossy compression and decompression methods, accuracy is so important. There will be a data loss but it should be under the limit of tolerance. It should be good enough for application of image processing. This kind of compression is used for transmitting or storing multimedia data, where compromise with the loss is allowed.

B. *Lossless image compression:*

In this type of compression, after decompression the images are almost the same as output images. It can allow the difference between the original image and the reconstructed image up to the certain predefined value. Lossless compression can be a valuable solution where we have strict constrains on the reconstruction. In addition, this method is useful where little information on each pixel is very important.

3: DISCRETE WAVELET TRANSFORM

The discrete wavelet transform usually is implemente d by using a hierarchical filter structure. It is applied to image blocks generated by the preprocessor. Two-dimension DWT leads to a decomposition of approximation coefficients at level j in four components: the approximation at level j+1, and the details in three orientations (horizontal,vertical, and diagonal).

After DWT transformation the subband is quantized to further compression and last the coefficient is entropy coded. DWT is used in JPEG 2000 while DCT is used in JPEG algorithm.

4: SPIHT ALGORITHM

SPIHT scans wavelet coefficients along quad –tree instead of sub band. Another modification is, SPIHT identifies significance only by the magnitude of wavelet coefficients and encodes the sign separately into a new bit stream. The number of bytes can be used to represent an image by using wavelet compression (EZW) is less as compared to JPEG compression .By the usage of SPIHT algorithm, we can improve the compression performance as compared to previous algorithms.

The SPIHT algorithm forms a hierarchical quadtree data structure for the wavelet transformed coefficients. The set of root node and corresponding descendents are referred to as a spatial orientation tree (SOT). The tree is defined in such a way that each node has either no leaves or four offspring, which are from 2 x 2 adjacent pixels. The pixels on the LL subimage of the highest decomposition level are the tree roots and are also grouped in 2 x 2 adjacent pixels. However, the upper-left pixel in 2 x 2 adjacent pixels has no descendant. Each of the other three pixels has four children.

For the convenience of illustrating the real implementation of SPIHT, the following sets of coordinates are defined.

(1) O(i, j): set of coordinates of all offspring of node (i, j);
(2) D(i, j): set of coordinates of all descendants of the node (i, j);
(3) H: set of coordinates of all spatial orientation tree roots (nodes in the highest pyramid level);
(4) L(i, j)=D(i, j)-O(i, j). (1)

Thus, except at the highest and lowest levels, we have

$$O(i, j) = \{(2i, 2j), (2i, 2j+1), (2i+1, 2j), (2i+1, 2j+1)\} . \quad (2)$$

Define the following function

$$S_n(\tau) = \begin{cases} 1, & \max\{|c_{i,j}|\} \geq 2^n, \\ 0, & \text{otherwise}, \end{cases} \quad (3)$$

Thresholds are a power of two, the encoding method can be regarded as "bit-plane" encoding of the wavelet coefficients. At stage *n*, all coefficients with magnitudes between T(n) and 2T(n) are identified as "significant," and their positions and sign bits are encoded. This process is called a *sorting pass*. Then, every coefficient with magnitude at least 2T(n) is "refined" by encoding the *n*th most significant bit. This is called a *refinement pass*. While in the LIS, each entry represents either the set D(i j) or L(i, j). An LIS entry is regarded as of type A if it represents D(i, j) and of type B if it represents L(i, j).

A. *SPIHT coding algorithm*

Step 1: (Initialization)

Output $n = \lfloor \log_2(\max_{(i,j)}\{|c_{i,j}|\}) \rfloor$, (4)

set the LSP as an empty list, $(i, j) \in H$

add the coordinates $(i, j) \in H$ to the LIP,

add the coordinates $(i, j) \in H$ with descendans to the list LIS, as type A entries,

Step 2: (Sorting Pass)

2.1) for each entry (i, j) in the LIP do:

output Sn(i, j),

if Sn(i, j)=1 move (i, j) to the LSP,

output the sign of $c_{i,j}$,

2.2) for each entry (i, j) in the LIS do:

2.2.1) if the entry is of type A then

output Sn(D(i, j)),
if Sn(D(i, j)) = 1 then
* for each $(i,j) \in O(i,j)$ do:
output Sn(k, l),
if Sn(k, l) = 1 then add (k, l) to the LSP,
output the sign of $c_{k,l}$,
if Sn(k, l)=0 then add (k, l) to the end of the LIP,
*if $L(i,j) \neq 0$ then
move (i, j) to the end of the LIS, as an entry of type B, go to Step 2.2.2).
otherwise remove entry (i, j) from the LIS,
2.2.2) if the entry is of type B output Sn(L(i, j)),
if Sn(L(i, j)) = 1 then ,*add each $(k,l) \in O(i,j)$ to the end of the LIS as an entry of type A, *remove (i,j) from the LIS,

Step 3: (Refinement Pass)
For each entry (i, j) in the LSP, except those included in the last sorting pass (i.e., with the same n), output the *n*th most significant bit of $|c_{i,j}|$.

Step 4: (Quantization-Step Update)
Decrement *n* by 1 and go to Step 2.

In the SPIHT algorithm, the transmission bit sequence at stage n is based only on the significant coefficients laying between *T(n)* and *2T(n)*.

5: PROPOSED DCTSPIHT AND MODIFIED DCTSPIHT SPIHT ALGORITHM

We have presented hybrid image compression algorithm by combining DCT and DWT. As most of image has information lies in low frequency region that implies slow variation of interpixel intensity. This approach used to minimize the wavelet coefficient region that is further reduce the maximum Threshold (T(n)) of SPIHT algorithm and that will reduce the time taken by algorithm. Further the most of coefficient of DCT is closed to zero so at low compression rate this will not create any bit stream through significant pass. In modified DCTSPIHT the bit streams generated by DCTSPIHT encoder will grouped into three bits and assign a unique symbol to it and pass through the Huffman entropy coder that further improve the compression ratio.

6: EXPERIMENTAL DATA

Various parameter of an image Evaluation and performance parameter like PSNR, Encoding and Decoding time and compression factor of SPIHT,DCTHPIHT and modified DCTSPIHT are illustrate here for comparison. We can see that proposed algorithm gives better PSNR, encoding and decoding time as compared to original SPIHT algorithm and modified DCTSPIHT algorithm gives better compression ratio at same PSNR

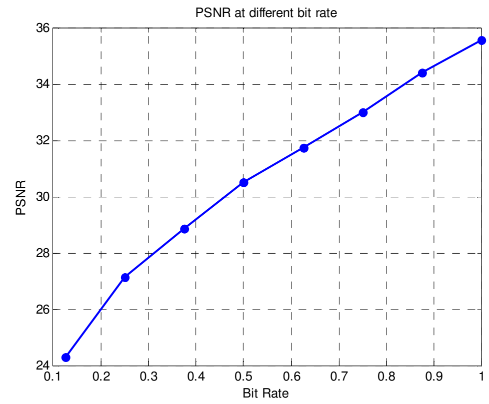

Fig.2 SPIHT PSNR verses Bit Rate

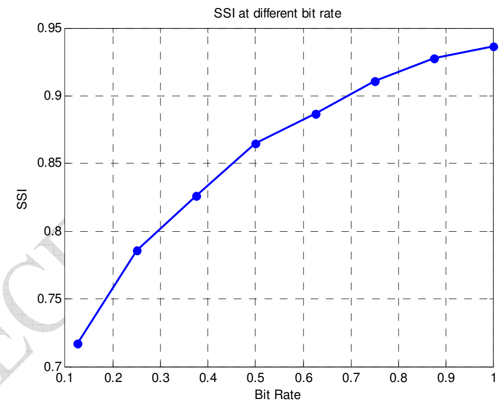

Fig.3 SPIHT SSIM verses Bit Rate

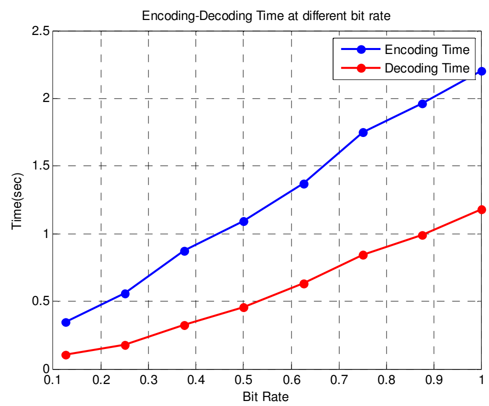

Fig.4 SPIHT Encoding and Decoding Time

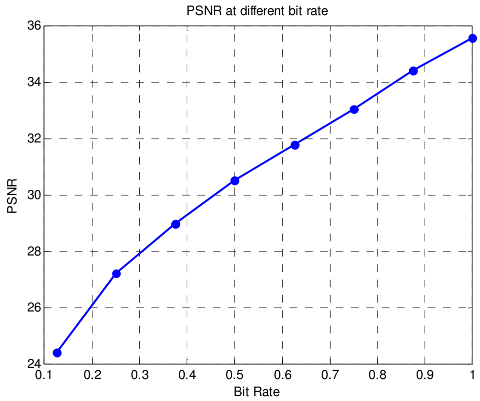

Fig.5 DCTSPIHT PSNR verses Bit Rate

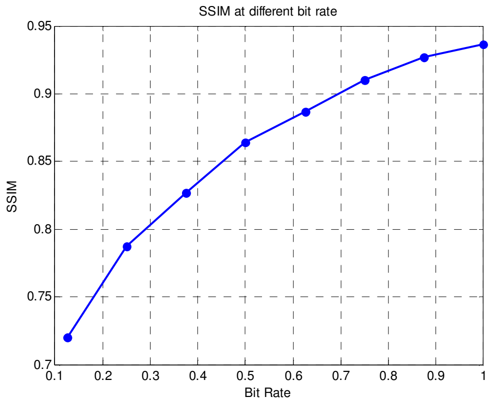

Fig.6 DCTSPIHT SSIM verses Bit Rate

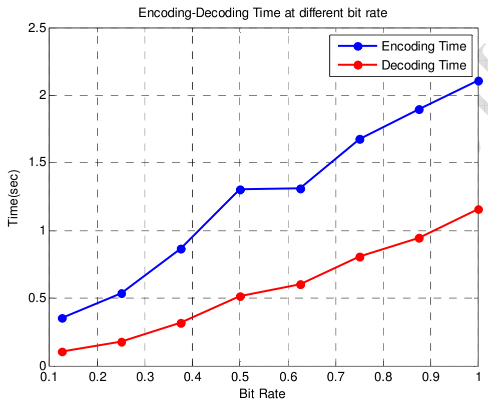

Fig.7 DCTSPIHT Encoding and Decoding Time

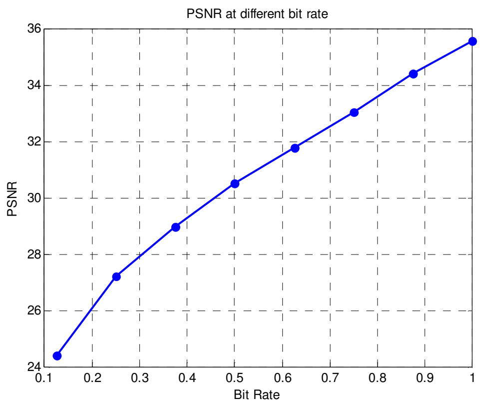

Fig.8 Modified DCTSPIHT PSNR verses Bit Rate

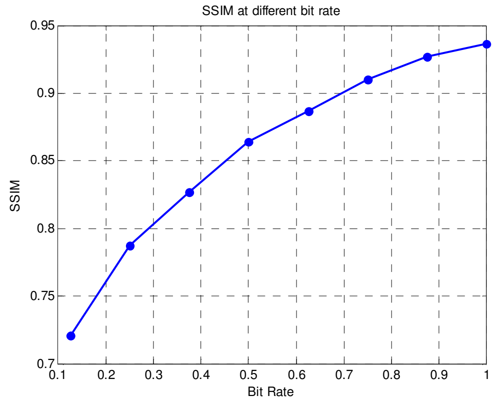

Fig.8 Modified DCTSPIHT SSIM verses Bit Rate

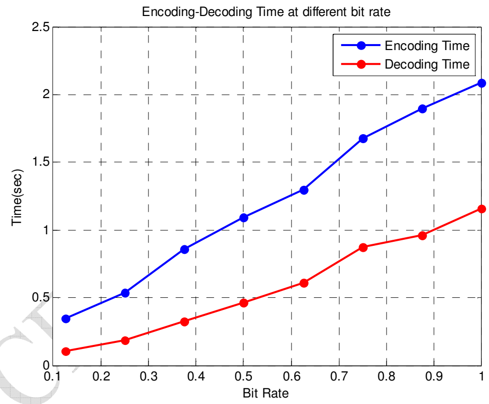

Fig.9 Modified DCTSPIHT Encoding and Decoding Time

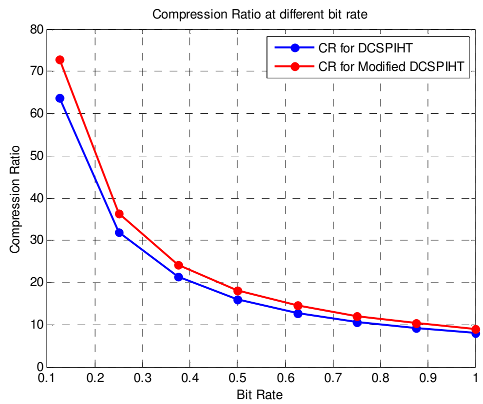

Fig.10 Compression Ratio for DCSPIHT and Modified DCTSPIHT

Table 5.1 Various Parameter of SPIHT and DCTSPIHT of a cameraman Image.

Bit Rate	Method	PSNR	SSIM	Encoding Time	Decoding Time
.125	SPIHT	24.30	71.73	0.35	0.11
	DCTSPIHT	**24.39**	**72.04**	**0.31**	**0.08**
.250	SPIHT	27.12	78.60	0.57	0.20
	DCTSPIHT	**27.20**	**78.73**	**0.54**	**0.17**
.5	SPIHT	30.49	86.47	1.24	0.48
	DCTSPIHT	**30.51**	**86.43**	**1.10**	**0.46**
.750	SPIHT	33.00	91.05	1.79	0.87
	DCTSPIHT	**33.02**	**91.01**	**1.76**	**0.83**
1	SPIHT	35.56	93.68	2.27	2.20
	DCTSPIHT	35.55	93.62	**2.17**	**1.17**

Table 5.2 Compression Ratio for DCTSPIHT and modified DCTSPIHT of Cameraman Image.

Bit Rate	Method	CR
.125	DCTSPIHT	63.84
	MODIFIED-DCTSPIHT	**72.77**
.250	DCSPIHT	31.96
	MODIFIED-DCTSPIHT	**36.42**
.50	DCSPIHT	15.99
	MODIFIED-DCTSPIHT	**18.16**
.750	DCSPIHT	10.66
	MODIFIED-DCTSPIHT	**12.03**
1	DCSPIHT	7.99
	MODIFIED-DCTSPIHT	**9.01**

7: CONCLUSION

Although the image compression is a trade off between compression ratio and peak signal to noise ratio, better and efficient compression-decompression techniques are still in demands in the image processing engineering. Using combination of DCT and DWT gives better image quality at low bit rate and at the same time performance can be improved. While compression can be improved further by Huffman entropy encoder (modified DCTSPIHT). Experimental results shows that our proposed approach gives better PSNR and less encoding and decoding time as compared to original SPIHT algorithm.

8: REFERENCES

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