

# A Hybrid Scheme for Medical Image Compression using SPIHT and DEFLATE Technique

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**ABSTRACT**-This paper presents the efficient medical image compression based on Set Partitioning in Hierarchical Trees (SPIHT) and Deflate algorithm. The analysis of compression time for implementing the LZW and Deflate compression techniques to the SPIHT encoded medical image to reduce the storage size is studied. Further, the compression ratio depends on various characteristics of the algorithm. The Proposed process is tested with different test medical images considering PSNR, MSE, Compression Ratio, and Compression Time for evaluation. Experimental results shows that the deflate algorithm has very less computation time compared to LZW leading to less CPU consumption and the cost of the algorithm is greatly reduced.

**Keywords:** Medical Image compression; SPIHT; Deflate algorithm;

## 1. INTRODUCTION

Due to the increase in digital information and the advancement in technology, the compression is the main area concentrated by most of the researchers. Advanced and efficient compression techniques are available, but based on the application, the best compression technique needs to be adopted. The compression may be lossy or lossless. In lossy compression the data bits are reduced, leading to the loss of information. In lossless compression, the bits are reduced by identifying and eliminating the statistical redundancy without loss of information. Compression not only concentrates on reducing the storage cost, but also reduces the bandwidth consumed when transmitting the image to the receiver. Currently there are a lot of advanced techniques which compress the images at a higher rate but the loss of information is identified. To go in detail with the study, the compression technique for the medical images is concentrated. For medical applications the lossless compression technique should be applied. In medical applications the lossy compression techniques is not applied since in the lossy compression technique the details of the image is not perfectly recreated. On applying the lossy compression technique to the image data, some parts of the image details are suppressed. Due to the loss of image data which may lead to the incorrect diagnosis, the lossy compression is not preferred for medical applications.

In this paper, the SPIHT based compression techniques used for medical images is analyzed and its characteristics are discussed. Further the SPIHT encoded Medical image is compressed with LZW and Deflate separately and the compression ratio, CPU time is studied.

The arithmetic coding applied on the SPIHT encoded images had better compression ratio by reducing the image storage size [1]. Yang et al. proposed a Hybrid scheme based on SPIHT and Huffman encoding. In this method, the lower magnitude bit-planes and the signed bit-plane are scanned node-by-node in the fixed order, and the bit stream is further compressed by using the Huffman encoder [2].

From [3] it is evident that there is an efficient approach for Medical Image compression using SPIHT and LZW. In this method the image is split into the bit planes and each bit plane image is enhanced using the histogram equalization and then the enhanced image is decomposed using the 2D FWT. The decomposed image is further compressed using the SPIHT. The resultant is further encoded with LZW technique to improve the compression ratio [3]

In all the above methods, the compression ratio is concentrated but the execution time for real time implementation is not calculated. Taking this as a goal, we are concentrating on the efficient method which has a better execution time and better compression ratio.

The rest of the paper is organized as follows. In section 2, Overview of SPIHT and Deflate is presented. In section 3, processing flow of the proposed algorithm has been provided. In Section 4, the simulation and comparative results of the study is discussed. In section 5, the conclusion of the paper is provided.

## 2. OVERVIEW OF SPIHT AND DEFLATE

In this section, the brief overview of the SPIHT and Deflate algorithm is presented.

### 2.1 Set Partitioning In Hierarchical Trees (SPIHT)

The most efficient algorithm in the area of image compression is the Set Partitioning in Hierarchical Trees (SPIHT). It uses a sub-band coder which produces a pyramid structure where an image is decomposed sequentially by applying power complementary low pass and high pass filters and then decimating the resulting images. These filters are one-dimensional filters that are applied in cascade (row then column) to an image whereby creating the four-way decomposition such as LL (low-pass then another low pass), LH (low pass then high pass), HL (high and low pass) and finally HH (high pass then another high pass). Such resulting LL version is again four-way decomposed. This procedure is repeated until the top of the pyramid is reached.

The most significant bit is firstly ordered and encoded and lastly processed to maintain the fine digital information of the reconstructed image. Sequence of sorting and refinement passes are applied to the decreasing magnitude thresholds. In the sorting pass, if the co-efficient is greater than or equal to the current magnitude threshold then it is considered to be significant bit. It is considered to be insignificant otherwise. For the significant bit, the co-efficient is immediately outputted. If the sign of the significant bit co-efficient is positive, then the SPIHT coder's output is 1, but it is passed as 0 to the output bit stream. For the insignificant nodes, SPIHT coder scans the co-efficient in a particular order. After completion of the scan in the sorting pass, the refinement pass process is conducted.

In the refinement pass process there are significant bit co-efficient which are not coded in the previous sorting pass process, they are been normalized with certain threshold. The three sets, List of Significant Pixels (LSP), List of Insignificant Pixels (LIP), and the List of Insignificant Sets (LIS) will be used in positioning of ordering nodes. At the first, the elements of the highest pyramid level are added to the LIP, the LIS is set to be the roots and LSP is set as the empty list. All the co-efficient of the LIP is firstly ordered and encodes the descents of the co-efficient in the LIS. After the completion of sorting of all the elements in LIP and LIS, the SPIHT will pass on to the next decomposition level by reducing the quantization threshold by half the value until it reaches 0.

The output bit stream of SPIHT encoding consists of a large number of seriate 0 situations. To avoid these redundancy bits we go for entropy encoding. In this paper we proposed Deflate technique to decrease the redundancy bits present in the bitstream obtained from the SPIHT encoding or compressed bitstream and reduce the compression time.

### 2.2 DEFLATE COMPRESSION

Deflate is a compression technique that combines LZ77 and Huffman together. The dictionary based algorithm similar to LZ77 is used for recurring sequences of the text. The Huffman code is used for entropy encoding. In simple words, it is a compression technique of two stages. In the first stage the dictionary based technique for the reoccurrence of the string is used. In the second stage the commonly used strings is replaced with the shorter representations and the less commonly used strings is replaced with the longer representation.

In the First stage, if the duplicate string is found from the given string then the current occurrence of the string is replaced with the pointer of the previous occurrence in the form of a distance, length pair. Distance is limited to 32K bytes and the length is limited to 256 bytes. Duplicate strings are found in the hash table. The hash table is searched starting from the commonly used strings to less commonly used strings thus taking the advantage of Huffman coding.

In the second stage, the method used is Huffman coding which creates an un-prefixed tree of non-overlapping intervals, where the length of each sequence is inversely proportional to the probability of that symbol needing to be encoded. The more likely a symbol has to be encoded, the shorter its bit-sequence will be.

## 3. PROCESSING FLOW OF THE PROPOSED ALGORITHM

The Proposed Hybrid Compression technique is processed as in the below steps.

- (1) The original images are captured from the standard image test database
  - (2) The reversible wavelet filter is chosen to transform the original images
  - (3) The sign bit-plane is scanned in the fixed order and the sign sequence is further treated by Deflate algorithm.
  - (4) The higher magnitude bit-planes, whose corresponding thresholds are more than 8, are encoded by the SPIHT coder.
  - (5) The remaining magnitude bit-planes, namely the lower magnitude bit-planes, are outputted in the order used in the sign bit-planes and the bit sequence is also encoded using Deflate method;
- If all coefficients are transmitted or the modified coder achieves the lossless compression of all image, the proposed coder.

The processing flow of the proposed system is explained through a block diagram in Figure 1.

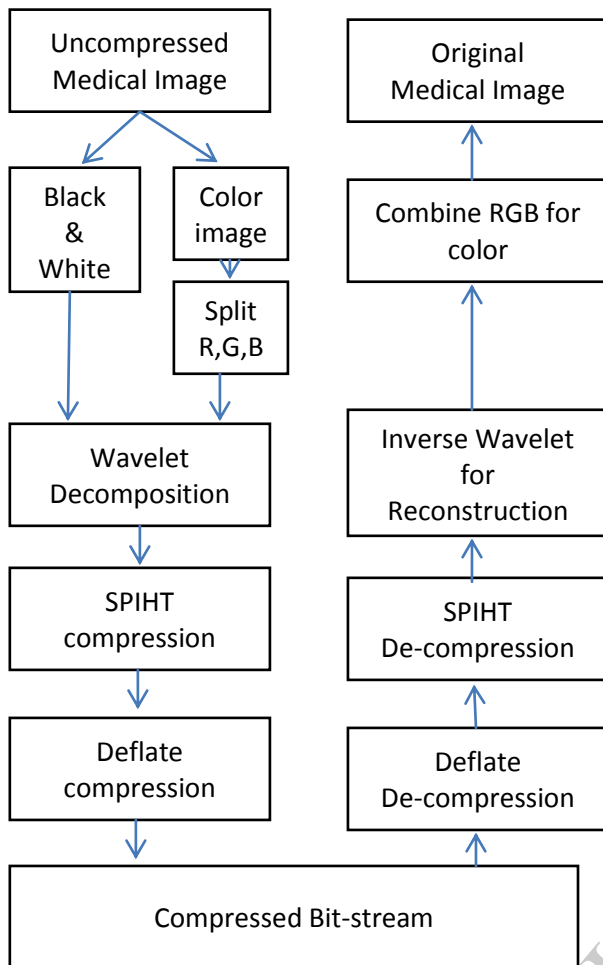


Figure 1: Proposed Block Diagram

#### 4. RESULTS AND DISCUSSION

Some experiments are performed to study the efficiency of the proposed architecture. The architecture was developed using MATLAB 7.14.0.739. The experiment was done on core i3 with 2.77 GHz, 3 GB RAM and full cache.

The performance of the compression technique is tested with different test Medical Brain images. The compression technique is tested in terms of compression ratio, compression size and the time elapsed for compression. Compression size is the size of the compressed file in bits after compression. Compression Ratio is the percentage obtained by dividing the compression size in bits by the original file size in bits.

The Quantitative performance of the proposed algorithm is evaluated based on Peak signal to noise ratio (PSNR), Mean Square Error (MSE) which is given in equations 1, 2 respectively.

$$PSNR = 10 \log_{10} \left( \frac{255^2}{MSE} \right) \quad (1)$$

$$MSE = \frac{\sum_i \sum_j (r_{ij} - x_{ij})^2}{M \times N} \quad (2)$$

Where  $r$  refers to Original image,  $n$  gives the corrupted image,  $x$  denotes restored image,  $M \times N$  is the size of Processed image.

The qualitative performance of the proposed Architecture is tested on various slices of brain images. Performance was calculated in terms of PSNR, MSE.

**TABLE I**

COMPARISON OF PSNR OF VARIOUS WAVELET FAMILIES APPLIED TO SPIHT ENCODER FOR TEST MEDICAL IMAGES

S.No	WAVELET FILTER TYPE	TEST IMAGE 1	TEST IMAGE 2	TEST IMAGE 3	TEST IMAGE 4	TEST IMAGE 5
1	Bior1.1	35.98	35.72	35.90	35.96	35.82
2	Bior1.3	35.56	35.25	35.50	35.53	35.37
3	Bior1.5	35.25	34.96	35.19	35.23	35.06
4	Bior2.2	39.13	39.03	39.23	39.27	39.21
5	Bior2.4	39.10	38.97	39.20	39.21	39.15
6	Bior2.6	38.99	38.87	39.09	39.09	39.04
7	Bior2.8	38.88	38.76	38.98	38.98	38.92
8	Bior3.1	37.70	37.67	37.74	37.80	37.81
9	Bior3.3	38.98	38.89	38.96	39.04	39.01
10	Bior3.5	39.27	39.16	39.26	39.29	39.29
11	Bior3.7	39.36	39.25	39.37	39.39	39.37
12	Bior3.9	39.38	39.30	39.39	39.39	39.39
13	Bior4.4	40.30	40.20	40.37	40.36	40.35
14	Bior5.5	40.14	40.03	40.14	40.13	40.04
15	Bior6.8	40.70	40.60	40.70	40.68	40.67

**TABLE II**

COMPARISON OF MSE OF VARIOUS WAVELET FAMILIES APPLIED TO SPIHT ENCODER FOR TEST MEDICAL IMAGES

S.No	WAVELET FILTER TYPE	TEST IMAGE 1	TEST IMAGE 2	TEST IMAGE 3	TEST IMAGE 4	TEST IMAGE 5
1	Bior1.1	16.42	17.40	16.72	16.50	17.01
2	Bior1.3	18.07	19.41	18.32	18.21	18.88
3	Bior1.5	19.43	20.75	19.69	19.52	20.28
4	Bior2.2	7.95	8.13	7.77	7.70	7.80
5	Bior2.4	8.00	8.24	7.82	7.79	7.91
6	Bior2.6	8.20	8.43	8.02	8.02	8.12
7	Bior2.8	8.41	8.66	8.23	8.23	8.33
8	Bior3.1	11.05	11.11	10.94	10.78	10.76
9	Bior3.3	8.23	8.39	8.27	8.11	8.16
10	Bior3.5	7.70	7.88	7.71	7.66	7.65
11	Bior3.7	7.53	7.73	7.53	7.48	7.52
12	Bior3.9	7.51	7.65	7.49	7.48	7.48
13	Bior4.4	6.07	6.21	5.97	5.99	5.99
14	Bior5.5	6.29	6.46	6.30	6.31	6.44
15	Bior6.8	5.53	5.66	5.53	5.55	5.57

The comparison of the PSNR and MSE for various Wavelet filter types used in SPIHT algorithm is discussed in Table I and Table II.

**TABLE III**

COMPARISON OF COMPRESSION RATIO, COMPUTATION TIME, FILE SIZE AFTER COMPRESSION WITH LZW AND DEFLATE FOR TEST MEDICAL IMAGES ENCODED WITH SPIHT ALGORITHM

Image	Original Size	LZW Compression Ratio(%)	LZW compression size	LZW Elapsed time	DEFLATE Compression Ratio(%)	DEFLATE Compression Size	Deflate Elapsed Time
Test Image 1	262144	0.58654	24601	11.6047	0.98336	41245	0.0881
Test Image 2	262144	0.58544	24555	17.1608	0.98195	41186	0.1507
Test Image 3	262144	0.58623	24588	17.1149	0.98265	41215	0.0935
Test Image 4	262144	0.58608	24582	13.4466	0.98448	41292	0.0899
Test Image 5	262144	0.58747	24640	12.0923	0.98579	41347	0.1628

The comparison of compression ratio, compressed file size and the time required to compress the file, between LZW and deflate algorithm is shown in Table III. The SPIHT encoded Test Medical images are used for the comparison in Table III. From Table III, LZW algorithm consumes more time on compressing but the size of the compressed file is less than the other technique and provides a better compression ratio. The processing time of deflate algorithm is much lesser than the LZW technique which is efficient for larger size files.

**TABLE IV**

COMPARISON OF COMPRESSION RATIO, COMPUTATION TIME, FILE SIZE AFTER COMPRESSION WITH LZW AND DEFLATE FOR TEST MEDICAL IMAGES WITHOUT ENCODING WITH SPIHT ALGORITHM

Image	Original Size	LZW Compression Ratio(%)	LZW Compression Size	DEFLATE Compression Ratio(%)	DEFLATE Compression Size
TEST IMAGE 1	262144	3.2551	136527	6.5019	272710
TEST IMAGE 2	262144	3.2561	136569	6.5125	273153
TEST IMAGE 3	262144	3.2124	134736	6.4048	268637
TEST IMAGE 4	262144	3.1408	131734	6.3243	265258
TEST IMAGE 5	262144	3.1348	131481	6.2898	263813

The comparison of compression ratio, compressed file size and the time required to compress the original image, between LZW and deflate algorithm is shown in Table IV. From Table IV, LZW algorithm consumes more time on compressing but the size of the compressed file is less than the other technique and provides a better compression ratio. The processing time of deflate algorithm is much lesser than the LZW technique which is efficient for larger size files.

## 5. CONCLUSION

In this paper, a Hybrid Two stage Medical Image compression is presented. The proposed technique of compressing the SPIHT encoded images with deflate compression technique results in significant reduction in size and better execution time of the Medical image without much loss of information. The primary goal of this paper is to reduce the execution time of the medical images. Our research on this is focused to reduce the execution time on compressing and provide a highly security to the digital information. From the analysis, it is found that the SPIHT algorithm will behave differently not only based on the characteristics of the image but also on the wavelet type. The bi-orthogonal wavelet 'Bior6.8' provides a better PSNR and this output is taken for further compression. From table III, it is found that the better execution time is obtained for the proposed algorithm along with the compression ratio.

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