

“SIMULINK BASED DESIGN AND IMPLEMENTATION OF MSPIHT”

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ABSTRACT: - Among all algorithms based on wavelet transform and zerotree quantization, set partitioning in hierarchical trees (SPIHT) algorithm is very efficient, has low computational complexity, and generates an embedded compressed bit-stream that can be efficiently decoded at several data rates (qualities). However, SPIHT's high memory requirement is a major drawback. In this study, a modification of SPIHT named Modified-SPIHT (MSPIHT) is presented. The MSPIHT coding algorithm is modified using Simulink model. Comparison of MSPIHT with SPIHT on different test images shows that for coding a 512×512, grey-level image, MSPIHT gives good peak signal-to noise ratio (PSNR) values and reduces memory.

KEYWORDS: Image Compression, SPIHT, DWT, MSE, MSPIHT, PSNR, CR.

I. INTRODUCTION: -

Among various compression techniques, wavelet-based technique provides substantial improvements in image quality at higher compression ratios. To achieve image compression wavelet transform provides a compact multi resolution representation and has excellent energy compaction property to exploit redundancy. The main characteristics of wavelets are their multi-resolution, multi-scale analysis, ability to have various time-frequency distributions, fundamental vanishing moment property, ability of the scaling functions to reproduce polynomials. Discrete wavelet transforms (DWT) is suitable for multi-resolution analysis. The “zerotree” coding technique is computationally simple and very effective in compression. In addition, its embedded coding property is beneficial to progressive transmission. In a related work, the original “zerotree” algorithm is called embedded zerotree wavelet (EZW), introduced by Shapiro. Said and Pearlman further enhanced the performance of EZW by presenting a more efficient and faster implementation called set partitioning in hierarchical tree (SPIHT). The SPIHT is one of the best algorithms in terms of peak signal-to noise ratio (PSNR).

1.1 DISCRETE WAVELET TRANSFORM

DWT makes use of frequency selective two channel filter bank (low-pass and high-pass) to decompose the input signal into low and high frequency bands referred to as subbands. For an image, 2D-DWT is calculated using a separable approach. Input image is first scanned in the horizontal direction and passed through low pass and

high pass decomposition filters producing low-frequency and high-frequency data in horizontal direction. The same filter-bank is then applied vertically to each column of the transformed image separately to generate different frequency sub-bands. The result is four subbands, LL (horizontally and vertically low-pass), LH (horizontally low-pass and vertically high-pass), HL (horizontally high-pass and vertically low-pass) and HH (horizontally and vertically high-pass) each with one-fourth the size of the original image. Most of the energy is concentrated in low-frequency subband LL, whereas higher frequency sub-bands LH, HL and HH contain detailed information of the image in vertical, horizontal and diagonal directions, respectively. For high level decomposition, DWT can be applied again to the LL sub-band recursively in a similar way to further compact energy into fewer low-frequency coefficients. After DWT, the decomposed data resembles a tree structure with different scales. A node (i.e. Transformed coefficient) at a coarser scale in wavelet tree is called a parent, whereas all nodes at the next finer scale of the same orientation are termed as children. When children of all the finer scales at the same orientation grouped together, they are known as descendants. A parent contains four children at its next level, with the exception at the highest level where a parent only contains three children and at the lowest level sub-bands has no children. A three-level wavelet decomposition of a block into sub-band is illustrated in Figure 1, whereas Figure 2 shows parent-child relationship among different levels of wavelet sub-bands.

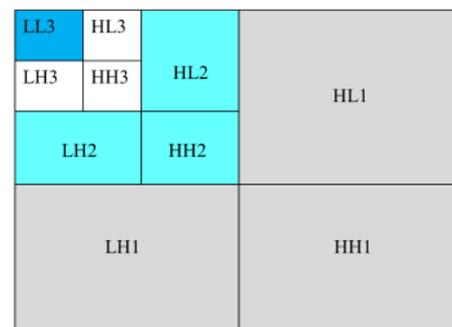


Figure 1 an image with 3 (2-D) DWT decomposition levels

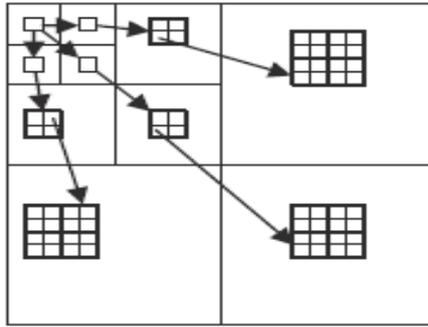


Figure 2. Relationship between higher and lower level coefficients

2. SET PARTITIONING IN HIERARCHICAL TREES: -

2.1 SPIHT ALGORITHM: -

SPIHT (Set Partitioning in Hierarchical Trees) is an image compressing algorithm associated with DWT, it uses principle of self-similarity across scale as an EZW. It is a method of coding and decoding the wavelet transform of an image. It has numerous attractive features, so it is an extremely powerful image compression algorithm. The SPIHT algorithm partitions the decomposed wavelet into significant and insignificant partitions based on the following function:

$$S_n(T) = \begin{cases} 1 & \max_{(i,j) \in TM} \{ |C_{(i,j)}| \} \geq 2^n \\ 0 & \text{otherwise} \end{cases}$$

Here $S_n(T)$ is the significance of a set of coordinate T and $C_{(i,j)}$ is the coefficient value at coordinate (i, j) .

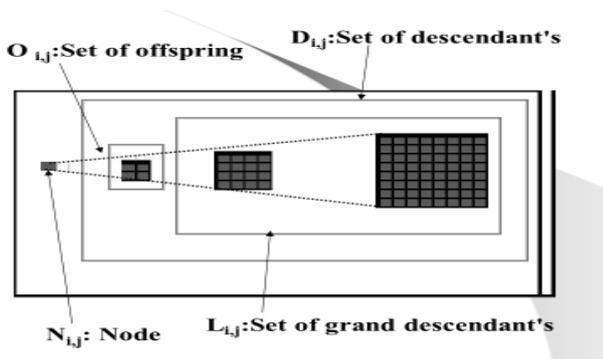


Figure 3 SOT of coefficients in SPIHT

The SPIHT algorithm defines four types of sets, which are sets of coordinates of coefficients:

- 1) $O(i, j)$ is the set of coordinates of the off springs of the wavelet coefficient at the location (i, j) .
- 2) $D(i, j)$ is the set of all descendants of the coefficients at the location (i, j) .
- 3) H is the set of all root nodes.

- 4) $L(i, j)$ is the set of coordinates of all descendants of the coefficients at the location (i, j) .

2.2 SPIHT introduces three lists of wavelet coefficients:

- 1) List of insignificant pixels(LIP): - It contains individual coefficients that have magnitudes smaller than the threshold. i.e. magnitudes < threshold.
- 2) List of significant pixels(LSP): - It is a list of pixels found to have magnitudes larger than the threshold (significant). i.e. magnitudes > threshold.
- 3) List of insignificant sets(LIS): - It contains set of wavelet coefficients that are defined by tree structures and are found to have magnitudes smaller than the threshold.

2.3 Flow chart of SPIHT: -

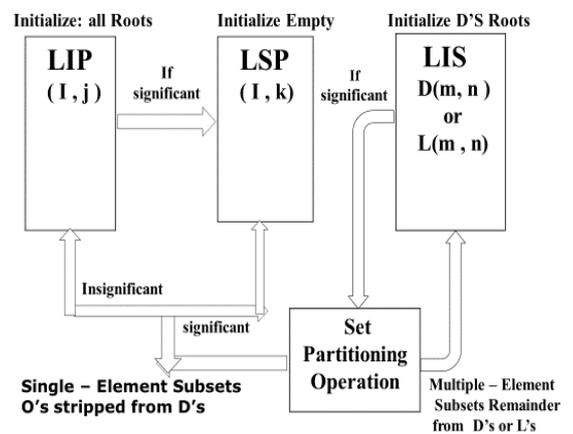
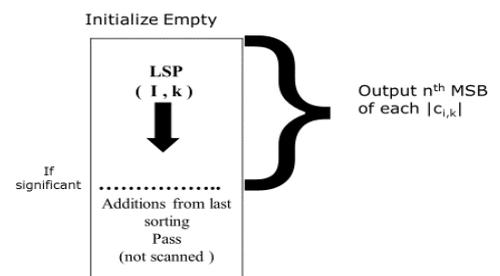


Figure 4 Operation of SPIHT

Step 1: Initialize

Initialize the threshold and order list Assign coefficients of all the root node in low-pass sub-band to LIP, all the trees are assigned to LIS and LSP is initialized to be an empty set.



Step 2: Sorting Pass

The aim is to encode the important coefficient of current bit. There are two main steps:

A) Check all the wavelet coefficients in LIP to determine whether they are important coefficients:

1) If it is yes, then output “1” and the sign bit, positive or negative sign bits of wavelet coefficients are represented by “1” and “0”, and then remove the coefficient from LIP and add to the end of order list LSP.

2) If it is not, we do not need to remove it from the list of LIP and give a direct output of “0”.

B) According to the type of trees, we shall check all the important trees in LIS:

Step 3: Refinement Pass

The aim is output but not the improving position of important factor in generated in the process of scanning. For each node (i, j) in LSP, if (i, j) is not just added during the scanning process, then absolute value |Ci, j| of the output of this node coefficient can be transmitted.

Step 4: Update the threshold

The maximum number of bits required to represent the largest coefficient in the spatial orientation tree is obtained and represented by n, which is $n = \lceil \log_2 c_{max} \rceil$, where c_{max} is the maximum value of coefficient. Update the threshold by decrement n by 1 and conduct the next level coding (back to step 2)

3 SIMULINK MODELS FOR MSPHIT: -

Simulink, developed by MathWorks, is an add-on product to MATLAB, provides an interactive, graphical environment for modelling, simulating, and analysing of dynamic systems. It includes a comprehensive library of pre- defined blocks to be used to construct graphical models of systems using drag-and-drop mouse operations. MATLAB program has only a command line-oriented interface while Simulink has a graphical interface where you can draw your element like in a plan. It supports system-level design, simulation, automatic code generation, and continuous test and verification of embedded systems. It is integrated with MATLAB enabling you to incorporate MATLAB algorithms into models and export simulation results to MATLAB for further analysis.

3.1 IMPLEMENTATION: -

The entire process of image compression goes through four phases which are explained as below: -

- 1) Image Pre-processing block.
- 2) Image parameter block.
- 3) Image encoding and decoding
- 4) PSNR analysis.

1. Image Pre-processing block: -

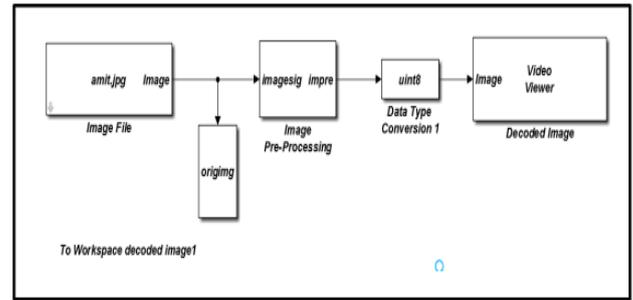


Figure 5. Block diagram of Image Pre-Processing.

As shown in Block Diagram the input image file fetches the original image from the system which we want to compress. The image pre-processing block converts input image to grey scale image and this data which is in 2-D is to be converted to 1-D. This image is processed further to convert it into intensity image (matrix image) with specified class and double data types for compatibility. The image video viewer block at output signal shows the converted image.

2. Image parameter block: -

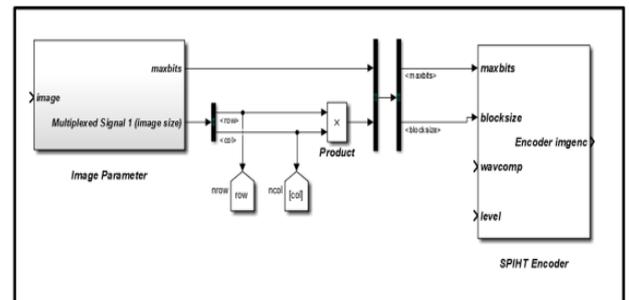


Figure 6. Block diagram of Image parameter.

In image parameter block, parameters of an image like maximum number of bits and block size are calculated. The row and column parameter are multiplied by product block and vector is passed to SPIHT encoder along with max bits for further processing.

3. Image encoding and decoding

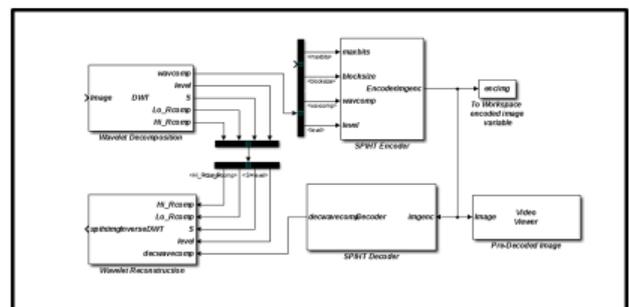


Figure 7. Block diagram of Image encoding and decoding

In DWT block image is decomposed in the pyramidal way with multi-decomposition with the number of significant and insignificant bits. SPIHT encoder block combines the image parameter in the form of block size, maximum bits and input from the DWT block i.e. Wavelet coefficients and the decomposition level to set up SPIHT encoding. Initialization of coefficients, sorting and refinement is done on these input parameters. And the output from the encoder gives the pre-decoded image. Then the SPIHT decoder decodes the encoded image obtained from the encoder block using SPIHT decoding algorithm. And the decoded wavelet components along with level, low pass and high pass filters and the bookkeeping matrix passed from the DWT block are passed to the IDWT block. This block recovers all the decoded wavelet components and the input from DWT and to convert the output in double for compatibility.

PSNR analysis: -

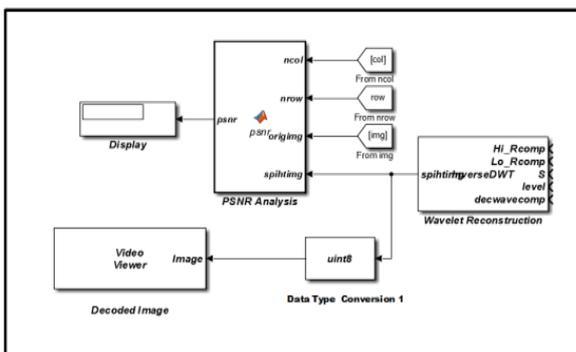


Figure 8. Block diagram of PSNR analysis.

IDWT parameters are passed through the data type conversion block. And finally, the decoded image is displayed. The quality of the decoded image is judge on the basis of the PSNR (Peak Signal to Noise Ratio) value. PSNR is an important parameter for image compression, it is a measurement of the peak error present between the compressed image and original image.

MEASURING PARAMETER: -

The performance parameters are measured in terms of CR, PSNR and MSE.

A. Peak Signal to Noise Ratio (PSNR): -

PSNR is defined as the ratio between maximum signal power to noise encountered in signal. For better quality of image PSNR should be as high as possible.

$$PSNR = 10 \log_{10} (Q \times Q / MSE) \text{ |db|}$$

Where Q X Q is the resolution of the uncompressed image.

B. Mean Square Error (MSE): -

Mean Square Error defined the Mean Squared Error between the compressed image and original image. MSE should be lower as possible for better quality of image. If MSE is 0 that mean compressed image is similar to uncompressed image and is given by

$$MSE = \frac{1}{N \times M} \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} [X(i, j) - Y(i, j)]^2$$

C. Compression Ratio: -

Compression Ratio (CR) is the ratio between pre-compression file size and post compression file size. Compression Ratio should be higher to achieve better compression.

$$\text{Compression Ratio} = \frac{\text{Original image Size}}{\text{Compressed image Size}}$$

IV.SIMULATION RESULT OF MSPHT:

The results obtained in MSPHT for images executed in MATLAB Simulink model are tabulated in Table 1 which shows original image, decoded image and pre-decoded image. Comparison of two methods MSPHT and SPIHT are tabulated below. Observation details shows that improved peak signal to noise ratio(PSNR) in Table and compression ratio (CR) is measured in table and graphical representation of both the table is also given.

Table 1: original, pre-decoded and decoded images.

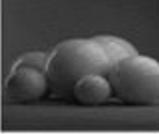
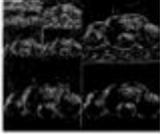
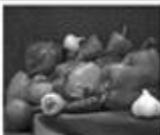
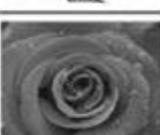
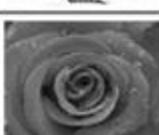
SR. NO	ORIGINAL IMAGE	DECODED IMAGE	PRE-DECODED IMAGE
1			
2			
3			
4			
5			

Table 2: Comparisons of PSNR

Sr. No	Image	SPIHT((PSNR)	MSPIHT(PSNR)
1	apple	42.25 dB	61.27 db.
2	ball	41.05 db.	56.16 db.
3	vegetable	37.02 db.	46.02 db.
4	tree	29.88 db.	51.54 db.
5	rose	30.86 db.	46.06 db.

V. CONCLUSION: -

The Simulink model based MSPIHT is a new application of image compression technique. It offers model-based design for processing and an ease of designing with GUI environment. It also supports software simulation which is important to avoid high level language for coding. This paper shows that the proposed system gives better PSNR and CR than SPIHT. This means that we have reduced the memory requirement. And in this model, we get output in the form of decoded image, also with pre-decoded image which can be used for future analysis.

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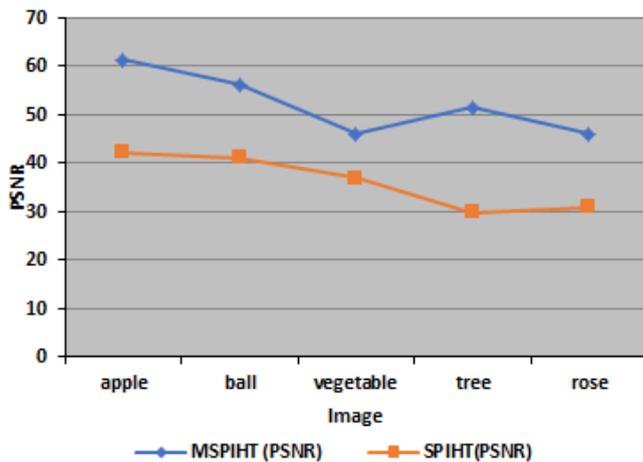


Figure 9 Graphical representation of PSNR

Table 3: Comparisons of Compression Ratio.

Sr.no	Image	SPIHT (CR)	MSPIHT (CR)
1	apple	1.1600	1.6194
2	ball	1.4900	2.5128
3	vegetable	3.1400	5.2888
4	tree	1.2200	1.5302
5	rose	1.6400	2.4388

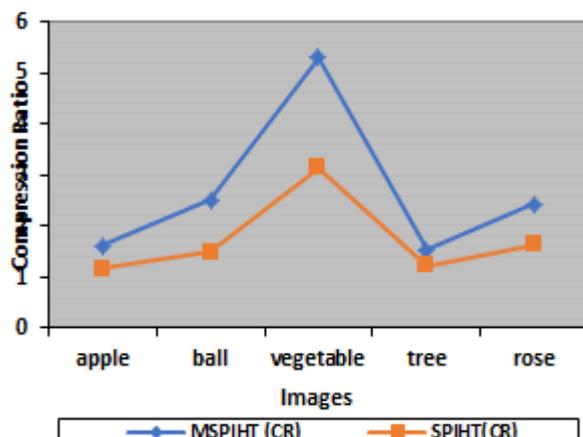


Figure 10 Graphical representation of CR.

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