Design and Implementation of Strip based Modified SPIHT algorithm for Compression and Decompression using Verilog

Yashaswini P R[1], Mr. Ravi Kiran H K[2]

[1]*M.Tech Student, Dept. of ECE, RIT, Hassan, Karnataka, India*
[2]*Assistant Professor, Dept. of ECE, RIT, Hassan, Karnataka, India*

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Abstract - *This work presents the implementation of modified SPIHT for the Compression and Decompression of the images. Even though SPIHT is known for its efficiency, it has got some memory limitations. In order to overcome that, the modified SPIHT will be used in this work that utilizes only a single list instead of three lists and the passes like sorting and refinement will be considered as a single pass. Initially images are first compressed using Haar wavelet transform where the whole image is divided into sub bands. After completing the Wavelet transform another entropy coding technique known as modified SPIHT has been applied to the resultant image to obtain the promising range in the values of factors such as Efficiency, Compression Ratio and PSNR which are the essential and imperative factors for the evaluation of performance. Since the image can't be taken directly as the input, it is first converted into text file and vice-versa using MATLAB code.*

Key Words: **Compression, Decompression, SPIHT, Compression ratio, PSNR**.

1. INTRODUCTION

Digital image processing refers to processing digital images by means of a digital computer. The image processing is motivated by two major applications, they are: Improvement of pictorial information for human perception in order to increase the image quality and effective storage of data and transmission. Usually the digital image processing users have to process a large data volume. Storing that data in order to utilize it in the future requires larger storage space. In same way transmission of the image needs wide channel capacity. For the reduction in these requirements, the image compression technique will be very useful. Therefore the scientific reduction in the image size where the necessary information and even the channel bandwidth needed for image representation is retained to save the storage space and to reduce transmission time is known as 'Image Compression'.

Mainly, compression is of two types,

- Lossless compression which is able to reconstruct the exact original data from the compressed data and the image quality is not reduced.
- Lossy compression in which the image that is original cannot be reconstructed back from the compressed data and the image quality is reduced.

Hybridizing the two best compression techniques gives much more better result. Set Partitioning in Hierarchical Trees (SPIHT) algorithm and HWT (Haar Wavelet Transform) techniques are one of the most efficient algorithms in image compression. The proposed work describes algorithm for implementation of techniques like SPIHT and HWT .

2. LITERATURE SURVEY

The author Venkata Anjaneyulu, P. Rama Krishna [1] in their paper gives brief theory of understanding how the image is compressed while transferring it from one end to the other, storage etc using DWT-SPIHT algorithm. While the author Richa Goyal [2] discusses different compression techniques in her survey paper. K Raghubad Bhattar [9] discusses an approach for lossless image compression in strip based embedded wavelet coding of coefficients for large images. V Vipin [3] has presented a design to perform real time image compression using SPIHT and arithmetic coding technique. Ping lui [5] in his work aimed at the shortage of SPIHT algorithm, by adopting lifting wavelet transform in order to overcome the shortcomings of decoding image quality and coding time.

3. METHODOLOGY

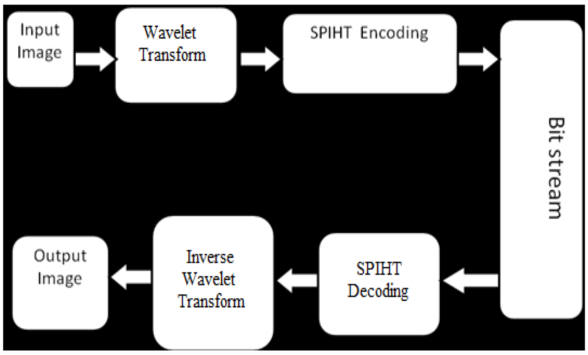

Fig -1: Block diagram of the entire process

Initially the image chosen is converted into text file using the MATLAB code. The converted image text file is stored in memory for further process. Then the pixels are read from the memory and it is applied to Haar wavelet transform and modified SPIHT algorithm for compression. Then after the compression process, decompression will be done by using the inverse techniques of both in order to get the image that is almost similar to the original image. Again the decoded pixel values are stored in memory. By using MATLAB code again, these values are converted from text file to image. Then the important specifications to measure the performance like CR, PSNR, MSE etc are calculated.

3.1 Haar wavelet transform

Wavelet transforms have turn out to be increasingly critical in image compression because wavelets allow both time and frequency analysis simultaneously. The wavelet transform plays an extremely important role in compression of image.

For applications in image compression, wavelet transform is a more suitable technique compared to the Fourier transform. Fourier transform is not practical for computing spectral data because it needs all previous and future data about the signal over the entire time domain and it cannot observe frequencies varying with time because the resulting function after Fourier transform is a function independent of time.

On the other hand, wavelet transforms are based on wavelets that are differing frequency in limited duration. The Wavelet Transform utilizes wavelets of finite energy. The Wavelet Transform, at high frequencies provides good time resolution and poor frequency resolution, whereas the Wavelet Transform at low frequencies provides good frequency resolution and poor time resolution.

Number of constructions of wavelets has been introduced in both mathematical analysis and in signal processing literature. In fact the interaction between these two is the main reason for the success of wavelets. In mathematical analysis, wavelets were originally constructed to analyze and represent geophysical signals using translates and dilates of one fixed function.

The transform of a signal is just another form of signal representation. It does not change the data content present in the signal. The wavelet transform gives a time-frequency signal representation. In order to overcome the short comings of Short Time Fourier Transform (STFT) it was developed.

There are various types of wavelets,

- Haar wavelet
- Morlet wavelet
- Daubechies wavelet

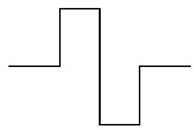

Fig -2: Haar wavelets

The Haar wavelet is the easiest transform among all the discrete wavelet transform and it is a sequential arrangement of rescaled functions that are "square-shaped" which together frame a wavelet family or premise. To some extent wavelet analysis is similar to Fourier analysis in that it permits a target function over an interval to be represented in terms of an orthonormal premise. The Haar sequential arrangement is currently perceived as the primarily known wavelet basis and widely utilized as an instructing illustration.

In 1909, Alfred Haar proposed the simplest wavelet transform known as the Haar sequence. Haar utilized these functions to provide a case as an example of an orthonormal framework for the space of square-integrable capacities on the unit interval [0, 1]. As a unique instance of the Daubechies wavelet, the Haar wavelet can also be called as Db1.

The Haar wavelet is additionally the most straightforward conceivable wavelet. The specialized inconvenience of the Haar wavelet is that it is not consistent, and in this way not differentiable. This property can, however, be leverage for the analysis and examination of signals with sudden transitions, such as checking of hardware failures in machines.

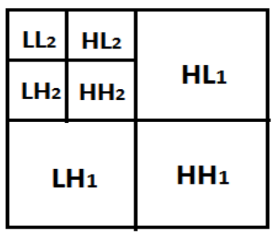

Fig -3: Sub band decomposition (2nd level)

The entire image is decomposed into sub bands called low-low(LL), low-high(LH), high-low(HL) and high-high(HH) in the first level. And in the second level the low-low(LL) sub band is further divided. LL is considered for further division because it contains the most useful information.

3.2 SPIHT Technique

SPIHT is a wavelet based image compression algorithm, proposed by Pearlman and Said in 1996. It is a powerful image compression algorithm that produces an embedded bit stream from which the best reconstructed images in the mean square error sense can be extracted at various bit rates. It is an efficient implementation of EZW (Embedded Zero Wavelet) algorithm.

After applying wavelet transform to an image, the SPIHT algorithm partitions the decomposed wavelet into significant and insignificant partitions. In set partitioning approach, the ordering information is not explicitly transmitted. Instead, the encoder and the decoder follow the same execution path and if the decoder receives the results of magnitude comparisons from the encoder, it can recover the ordering information from the execution path.

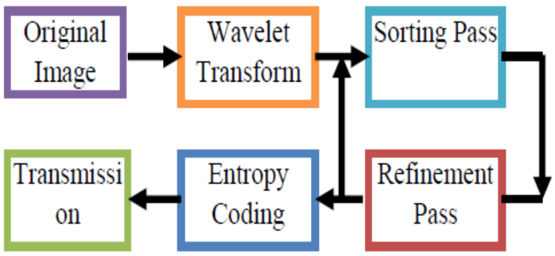

Fig -4: Block diagram of SPIHT

The SPIHT encoding process utilizes three lists

- *LIP* (List of Insignificant Pixels) – It consists of individual elements that have magnitudes lesser than the thresholds
- *LIS* (List of Insignificant Sets) – It contains set of wavelet elements and are found to have magnitudes lesser than the threshold.
- *LSP* (List of Significant Pixels) – It consists of pixels that are found to have magnitudes larger than the threshold.

Every pass is subdivided into,

Sorting Pass: The sorting pass encodes the coefficients that are insignificant in the earlier pass and may be significant in the next passes when the threshold value decreases.

Result is passed to the output and then the significant ones out of it will be placed in the LSP along with the sign bit. LIS is also made to pass through the significance test and if found significant, they will be removed and partitioned into subsets. Subsets that are observed to be significant with one and only one coefficient will be divided into subsets. Subsets having one and only one element and is found to be significant, then it will be added to the significant pixel list; otherwise it will be given to insignificant pixel list.

Refinement Pass: In the refinement pass, the nth MSB of the coefficients in the LSP is the final output. The coefficients that are already significant in the initial passes, are magnitude refined in a process of approximation.

Passes will keep on continuing until either the desired rate is reached or $n = 0$ and all nodes in significant pixel list have all their bits output.

The latter case will provide an almost exact reconstruction because all the elements have been processed completely. The rate of bits could be controlled exactly in the SPIHT technique as the output produced is in single bits and the process can be finished at any time.

The image is divided into approximation and detail sub images. Therefore first filter is applied along the columns and then applied along the rows. Thus the operation results in four bands namely low-low(LL), low-high(LH), high-low(HL) and high-high(HH). Each column of an M*N image is filtered and then down sampled which gives two N*M/2 images. Then each row is filtered and sub sampled which gives four N/2*M/2 images of these four sub images, the one obtained by low pass filtering rows and columns is referred as LL image, the one obtained by low pass filtering rows and high pass filtering the columns is referred as LH image, the one obtained by high pass filtering rows and low pass filtering the columns is referred as HL image and the other one obtained by high pass filtering rows and columns is referred as HH image.

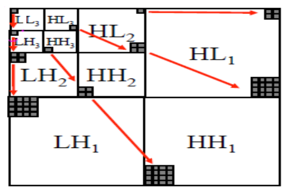

Fig -5: Spatial Orientation Trees

The bits are then segregated as significant and insignificant lists. To obtain the compressed image sorting and refinement pass are then applied on the lists.

SPIHT decoding is similar and inverse procedure to that of encoding process.

In the Modified SPIHT process, in order to overcome the memory limitations of the SPIHT process, it utilizes only a single list instead of three lists and the sorting and refinement passes are considered as a single scan pass by a technique called strip logic where only some bits of the image are processed at once instead of entire image. In the proposed work the enhancement in the diverse entropy coding system called Modified SPIHT procedure is used.

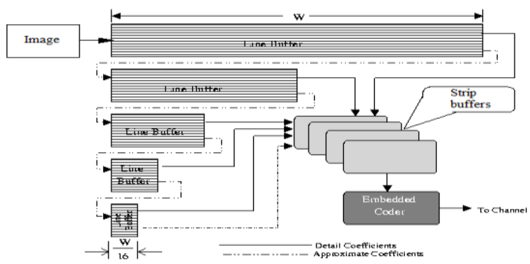

Fig -6: Strip logic

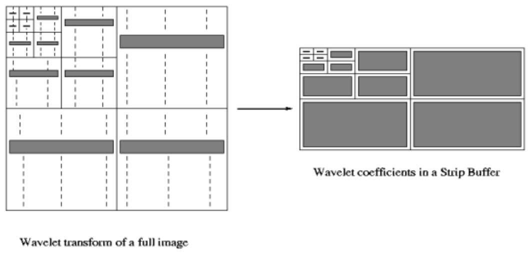

Fig -7: Formation of Strips

4. IMPLEMENTATION OF WAVELET TRANSFORM AND MODIFIED SPIHT TECHNIQUE

In this work, simulation results can be seen in ModelSim that is a HDL simulation environment that supports multiple languages and is provided by Mentor Graphics, for simulation of hardware description languages such as VHDL, Verilog and SystemC. This can be invoked by MATLAB through the socket server. ModelSim simulator 6.3g_p1 will be used in this work.

Using the MATLAB source code initially any database image is converted into txt.file format. For further process the converted file is stored in the memory.

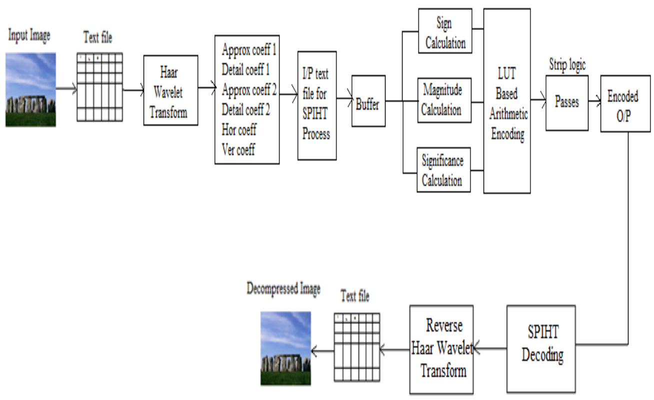

Fig -8: Implementation of Haar wavelet transform Modified SPIHT technique

Once the full memory is read, the counter is reset and begins counting from the starting. In this work the process is done on the 256×256 image. Hence, primarily the image of any size is made to the size of 256×256. Then the even and odd pixels are separated and stored in different memory locations by using a counter. Then the pixels are further stored in a register and applied on Haar Wavelet Transform technique. Then the output of this is given to the strip logic based Modified SPIHT coding technique for further process.

In the Haar Wavelet transform technique, if start is 1, then it sends the value of im11(even) and im21(odd) to im11t and im21t respectively and if reset is 1, it clears both the im11t and im21t. It checks if im11t> im21t and if so, it performs, im11t - im21t and if im11t < im21t, it performs im21t – im11t and stores the values to corresponding text files. Then the output of wavelet transform is given to the Modified SPIHT coding technique for further process. The coded image will be decoded by utilizing the inverse techniques of the techniques used in the coding part in order to get the original image. These values are then converted from text file to image in MATLAB. The flow diagram of the entire process is as shown in Fig 9

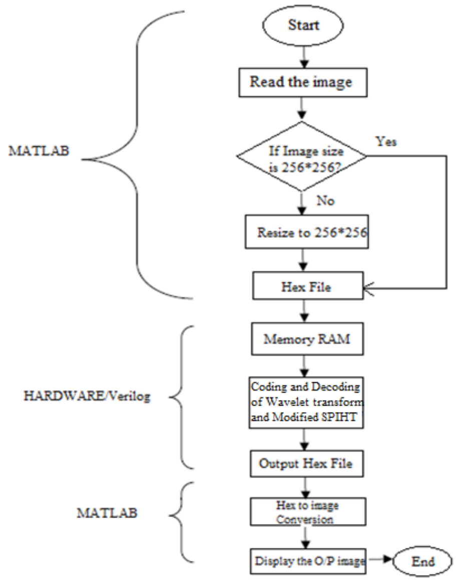

Fig -9: Flow diagram of the entire process

5. RESULTS AND DISCUSSION

5.1 Verilog Simulation Results

In this paper, Xilinx is used to write the verilog code which has to be then compiled with zero errors. A test bench code is written in Verilog. Then by using that the design can be verified using ModelSim software functionally. In order to convert image into text file and vice-versa a MATLAB code has been written. Design and testing of Wavelet transform and Modified SPIHT algorithm has been carried out and is described in verilog. Fig 10 depicts the simulation results in ModelSim software for compression

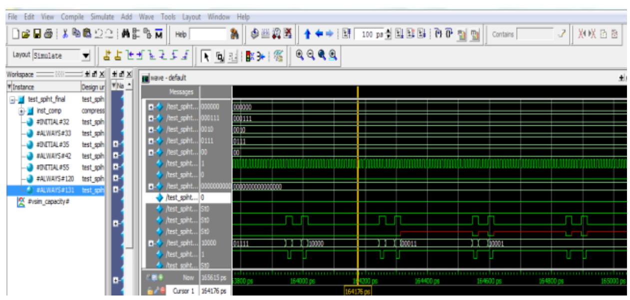

Fig -10: Simulation result of Haar wavelet transform and enhanced SPIHT Technique for compression

Decompression takes place by using the inverse techniques like Inverse wavelet transform and Modified SPIHT decompression. Fig 11 depicts the simulation results in ModelSim software for Inverse wavelet transform and Modified SPIHT technique for decompression

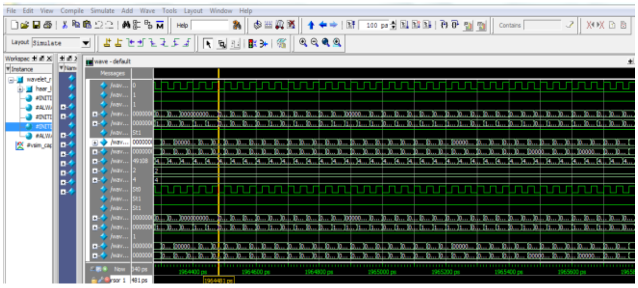

Fig -11: Simulation result of Haar wavelet transform and enhanced SPIHT Technique for decompression

In the hardware synthesis part, the RTL view of the entire design can be seen. Fig 12 shows the Register Transfer Logic view of the entire project.

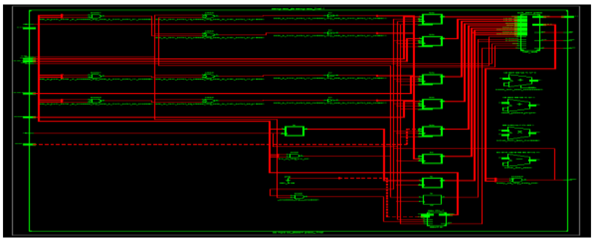

Fig -12: RTL view of the entire project

5.2 Matlab Simulation Results

Fig 13 shows the input image for techniques like HWT and Modified SPIHT and the simulation output of Wavelet transform and Modified SPIHT for Compression in MATLAB software.

Input Image Image Compressed

Fig -13: Compression output in MATLAB window

Fig 14 shows the simulation output of decompression in MATLAB software.

Fig -14:Decompression output in MATLAB window

The PSNR Performance for the above image using Wavelet transform and SPIHT technique is **52.1 dB** and MSE is **44.2dB**.

Various values of Compression Ratio, Efficiency, ET and DT for the whole project is as shown in Table 1.

Sl.no	Specifications	Values
1	CR	72.28dB
2	Efficiency	96.16dB
3	Encoding time	6.441ns
4	Decoding time	7.316ns

Table-1: Specifications

3. CONCLUSION AND FUTURE ENHANCEMENT

The proposed work is mainly focused on the techniques like Haar wavelet transform and modified SPIHT. Wavelet transform along with modified SPIHT technique improves the desired specifications like PSNR, MSE and so on. Haar wavelet transform makes itself a standard technique for its high efficiency. SPIHT which provides variety of important characteristics like good image quality, high PSNR etc., along with HWT technique makes the proposed work a very efficient design.

As a part of the future work, the project could be implemented for images of sizes like 512×512, 1k ×1K or even more. Number of decomposition levels can be increased that may provide still better result.

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REFERENCES

[1] I. Venkata Anjaneyulu, P. Rama Krishna, "FPGA Implementation of DWT-SPIHT Algorithm for Image Compression", International Journal of Technology Enhancements and Emerging Engineering Research, 2015

[2] Richa Goyal, SouravGarg, "Lossless image compression using Data Folding followed by Arithmetic Coding" , IOSR-JCE, March-April 2015, PP. 67-70.

[3] Mr.Vipin V, Miranda Mathews, "FPGA Implementation of Image Compression using SPIHT technique" , IJAREEIE 2014, PP. 7001-7007.

[4] Rema N.R, Binu Ani Oommen, Mythili P, "Image compression using SPIHT with modified spatial orientation trees" , ICICT, 2014, PP. 1732-1738.

[5] Ping Liu, Guanfeng Li, "An Improved SPIHT Algorithm for Image Compression in Low Bit Rate", Scientific Research, 2013, PP. 245-248.

[6] Thomas W. Fry Scott Hauck, "SPIHT Image Compression on FPGAs" , 2013.

[7] K. Harika, K.V. Ramana Reddy, "Design and Implementation of Arithmetic Coder used in SPIHT", International Journal of Innovative Technology and Exploring Engineering (IJITEE), 2013, PP. 119-124.

[8] Gayatri B. Tigadi & Manjuladevi T.H, "Lossless And Lossy Image Compression Based on Data Folding" , IJEEE, 2012.

[9] K. Raghunad Bhattar, K.R, Ramakrishnan and Dasguptha K.S, "Strip based embedded coding of wavelet coefficients for large images", IISC, 2013

[10] Nikola Sprljan, Sonja Grgic, "Modified SPIHT algorithm for wavelet packet image coding", 2005, PP. 378-388.

BIOGRAPHY

Yashaswini P R, M. TECH in the stream of VLSI Design and Embedded Systems (VLSI), Rajeev Institute of Technology, Hassan, Karnataka