ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

DESIGN AND IMPLEMENTATION OF GENERIC 2-D BIORTHOGONAL DISCRETE WAVELET TRANSFORM ON FPGA

Prof (Dr.) Prakash.H.Patil*, N.S.Mhamunkar
* H.O.D., Department of E&TC, ICEM Parandwadi Pune, India
M.E. Student,Department of E&TC, ICEM ParandwadiPune, India

ABSTRACT

We propose a highly scalable image compression scheme based on the set partitioning in hierarchical trees (SPIHT) algorithm. Our algorithm, called highly scalable SPIHT (HS-SPIHT), supports spatial and SNR scalability and provides a bitstream that can be easily adapted (reordered) to given bandwidth and resolution requirements by a simple transcoder (parser). The HS-SPIHT algorithm adds the spatial scalability feature without sacrificing the SNR embeddedness property as found in the original SPIHT bitstream. HS-SPIHT finds applications in progressive Web browsing, flexible image storage and retrieval, and image transmission over heterogeneous networks.

KEYWORDS: FPGA, Generic 2-D biorthogonal discrete

INTRODUCTION

One of the major challenges in enabling mobile multimedia data services will be the need to process and wirelessly transmit a very large volume of data. While significant improvements in achievable bandwidth are expected with future wireless access technologies, improvements in battery technology will lag the rapidly growing energy requirements of future wireless data services. One approach to mitigate to this problem is to reduce the volume of multimedia data transmitted over the wireless channel via data compression techniques.

This has motivated active research on multimedia data compression techniques such as JPEG [1,2], JPEG 2000 [3,4] and MPEG [5]. These approaches concentrate on achieving higher compression ratio without sacrificing the quality of the image. However these efforts ignore the energy consumption during compression and RF transmission.

Today a lot of hospitals handle their medical image data with computers. The use of computers and a network makes it possible to distribute the image data among the staff efficiently. As the health care is computerized new techniques and applications are developed, among them the MR and CT techniques. MRand CT produce sequences of images (image stacks) each a cross-section of an object. The amount of data produced by these techniques is vast and this might be a problem when sending the data over a network. To overcome this the image data can be compressed. For two-dimensional data there exist many compression techniques such as JPEG, GIF and the new wavelet based JPEG2000 standard [7]. All schemes above are used or two-dimensional data (images) and while they are excellent for images they might not be that well suited for compression of three-dimensional data such as image stacks.

The purpose of this paper is to look at coding schemes based on wavelets for medical volumetric data. The thesis should discuss theoretical issues as well as suggest a practically feasible implementation of a coding scheme. A short comparison between two- and three-dimensional coding is also included.Another goal is to implement highly scalable image compression based on SPIHT.

PRINCIPAL OF COMPRESSIONS

Image compression addresses the problem of reducing the amount of data required to represent a digital image. The underlying basis of the reduction process is the removal of redundant data. From a mathematical viewpoint, this amounts to transforming a 2-D pixel array into a statistically uncorrelated data set. The transformation is applied prior to storage and transmission of the image. The compressed image is decompressed at some later time, to reconstruct the original image or an approximation to it.

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

Different types of data redundancies:

- Interpixel redundancy: Neighboring pixels have similar values. This property is exploited in the wavelet transform stage.
- Psychovisual redundancy: Human distinguish all colors. This property is visual system cannot simultaneously exploited in the lossy quantization stage.
- Coding redundancy: Fewer bits represent frequent symbols.

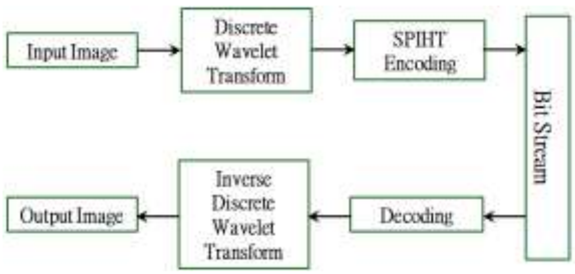

Fig 1 Image compression Diagram

The image sample first goes through a transform, which generates a set of frequency coefficients. The transformed coefficients are then quantized to reduce the volume of data. The output of this step is a stream of integers, each of which corresponds to an index of particular quantized binary. Encoding is the final step, where the stream of quantized data is converted into a sequence of binary symbols in which shorter binary symbols are used to encode integers that occur with relatively high probability. This reduces the number of bits transmitted.[1]

There are various algorithms for image transformation:

Discrete cosine transform (DCT)
JPEG
Sub-band coding
Embedded zero wavelet transform (EZW)
SPIHT

DISCRETE WAVELET TRANSFORM

Wavelet coding has become very popular due to its robustness under transmission and decoding errors at higher compression rates avoiding blocking artifacts. Wavelet based compression is based on subbandcoding. Sub band coding involves splitting thefrequency band of the image into sub bands and then to code each sub band using a coder and bit rate accurately matched to the statistics of the band. Simple DWT consists of a low pass filter and high pass filter which splits the image into low frequency and high frequency sub bands.[9]

Figure 2 shows the two dimensionaldecomposition of image where the first one is row decomposition and the second stage is column decomposition.

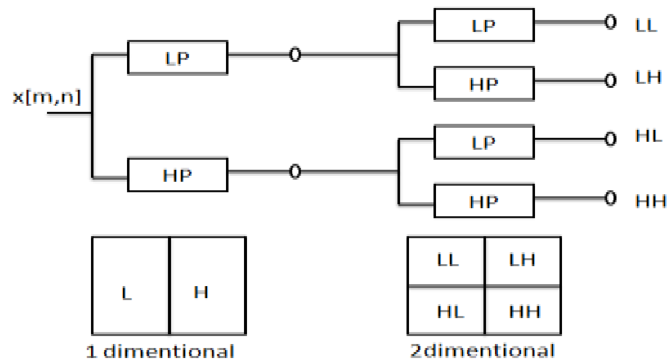

FIGURE 2 .2-D DWT [8]

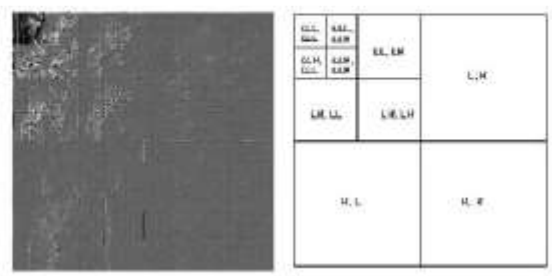

FIGURE 3.Representation of decomposed image [8]

Decomposition is done till the imagedecomposes to 4x4 block. Figure 3 shows the decomposed image where the low frequencies are at the top left corner of the image and purely higher frequency at bottom right corner.

WAVALET COMPRESSION STEPS

The steps needed to compress an image are as follows:

1. Digitize the source image into a signal, which is a string of numbers.
2. Decompose the signal into a sequence of wavelet coefficients.
3. Use quantization to convert coefficients to a sequence of binary symbols.
4. Apply entropy coding to compress it into binary strings.[2]

The first step in the wavelet compression process is to digitize the image. The digitized image can be characterized by its intensity levels, or scales of gray that range from 0 (black) to 255 (white), and its resolution, or how many pixels per square inch. The wavelets process the signal, but upto this point, compression has not yet occurred. The next step is quantization which converts a sequence of floating numbers to a sequence of integers. The simplest form is to round to the nearest integer. Another option is to

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

multiply each number by a constant and then round to the nearest integer. Quantization is called lossy because it introduces error into the process, since the conversion is not a one-to-one function. The last step is encoding that is responsible for the actual compression. One method to compress the data is Huffman entropy coding. With this method, an integer sequence, is changed into a shorter sequence, with the numbers being 8 bit integers. The conversion is made by an entropy coding table.[2]

PR0P0SED SPIHT

SPIHT was introduced in [9]. It is a refinement of the algorithm presented by Shapiro in [10]. SPIHT assumes that the decomposition structure is the octave-band structure and then uses the fact that sub-bands at different levels but of the same orientation display similar characteristics. As is seen in Figure 4 the band LL HL has similarities with the band HL (both have high-pass filtered rows). To utilize the above observation SPIHT defines spatial parent-children relationships in the decomposition structure. The squares in Figure 4 represent the same spatial location of the original image and the same orientation, but at different scales. The different scales of the subbands imply that a region in the sub-band LL HL is spatially co-located (represent the same region in the original image) with a region 4 times larger (in the two dimensional case) in the band HL. SPIHT describes this collocation with one to four parent-children relationships, where the parent is in a sub-band of the same orientation as the children but at a smaller scale .If. this prediction is successful then SPIHT can represent the parent and all its descendants with a single symbol called a zero-tree, introduced in [10]. To predict energy of coefficients in lower level sub-bands (children) using coefficients in higher level sub-bands (parents) makes sense since there should be more energy per coefficient in these small bands, than in the bigger ones. To see how SPIHT uses zerotrees the workings of SPIHT are briefly explained below. For more information the reader is referred to [9].

SPIHT consists of two passes, the ordering pass and the refinement pass. In the ordering pass SPIHT attempts to order the coefficients according to their magnitude. In the refinement pass the quantization of coefficients is refined. The ordering and refining is made relative to a threshold. The threshold is appropriately initialised and then continuously made smaller with each round of the algorithm. SPIHT maintains three lists of coordinates of coefficients in the decomposition. These are the List of Insignificant Pixels (LIP), the List of Significant Pixels (LSP) and the List of Insignificant Sets (LIS). To decide if a coefficient is significant or not SPIHT uses the following definition. A coefficient is deemed significant at a certain threshold if its magnitude is larger then or equal to the threshold. Using the notion of significance the LIP, LIS and LSP can be explained. The LIP contains coordinates of coefficients that are insignificant at the current threshold, The LSP contains the coordinates of coefficients that are significant at the same threshold.The LIS contains coordinates of the roots of the spatial parent-children trees .

1. In the ordering pass of SPIHT (marked by the dotted line in the schematic above) the LIP is first searched for coefficients that are significant at the current threshold, if one is found 1 is output then the sign of the coefficient is marked by outputting either 1 or 0 (positive or negative). Now the significant coefficient is moved to the LSP. If a coefficient in LIP is insignificant a 0 is outputted.
2. Next in the ordering pass the sets in LIS are processed. For every set in the LIS it is decided whether the set is significant or insignificant. A set is deemed significant if at least one coefficient in the set is significant. If the set is significant the immediate children of the root are sorted into LIP and LSP depending on their significance and 0s and 1s are output as when processing LIP. After sorting the children a new set (spatial coefficient tree) for each child is formed in the LIS. If the set is deemed insignificant, that is this set was a zero-tree, a 0 is outputted and no more processing is needed. The above is a simplification of the LIS processing but the important thing to remember is that entire sets of insignificant coefficients, zero-trees, are represented with a single 0. The idea behind defining spatial parent-children relationships as in (FIG 4) is to increase the possibility of finding these zero-trees.
3. The SPIHT algorithm continues with the refinement pass. In the refinement pass the "next bit" in the binary representation of the coefficients in LSP is outputted. The "next bit" is related to the current threshold. The processing of LSP ends one round of the SPIHT algorithm, before the next round starts the current threshold is halved.

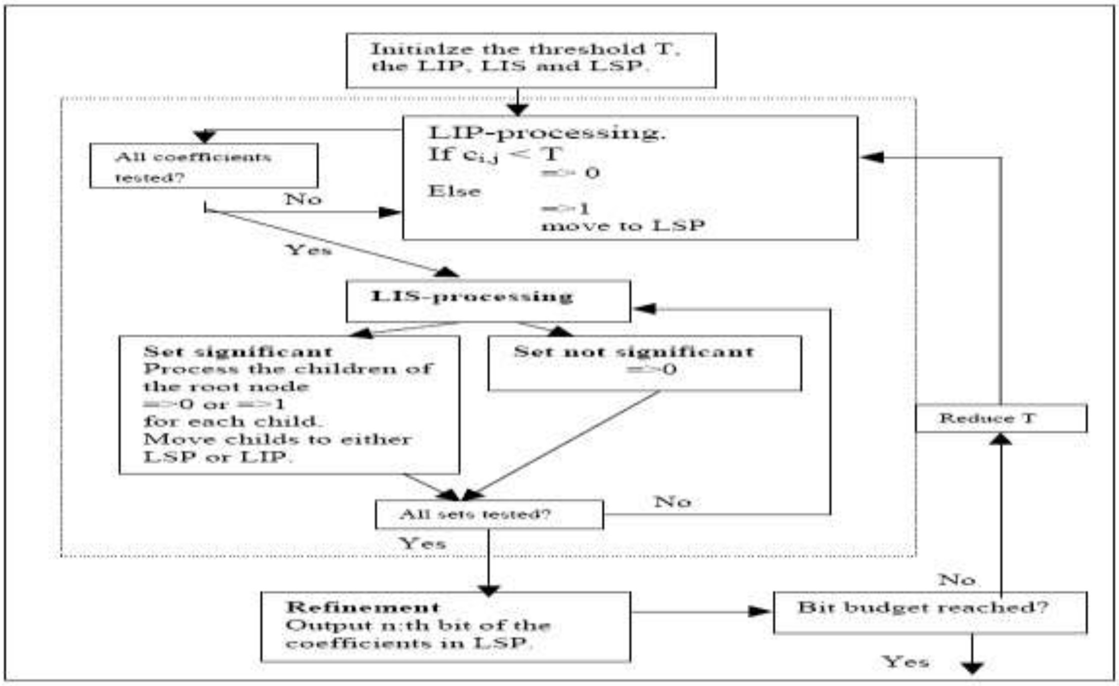

FIGURE 4 BLOCK SCHEMATIC OF SPIHT ALGORITHM

FPGA IMPLEMENTATION

FPGAs are an array of logic gates, which can be programmed to perform variety of tasks. FPGA offers a low cost ,high speed and flexible solution over ASICs. A single FPGA can be used for many tasks, it is fabricated inhighervolume, which reduce fabrication costs. Also we can reprogram, and which allows design modification and bug fixes without the need to construct a new hardware system. Reprogramming takes only few milliseconds.

Spartan 3E FPGA is used in our project. The main advantages are high speed connectivity, high performance DSP solutions and low cost. The software used for FPGA implementation is Xilinx ISE 10.1. There are softcoremicroprocessor(MicroBlaze) and hard core embedded microprocessors (PowerPC). MicroBlaze is a virtual microprocessor that includes the following properties.

- Thirty- two 32-bit general purpose registers
- 32- bit address line
- Single issue pipeline
- Separate 32-bit instruction and data bus

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

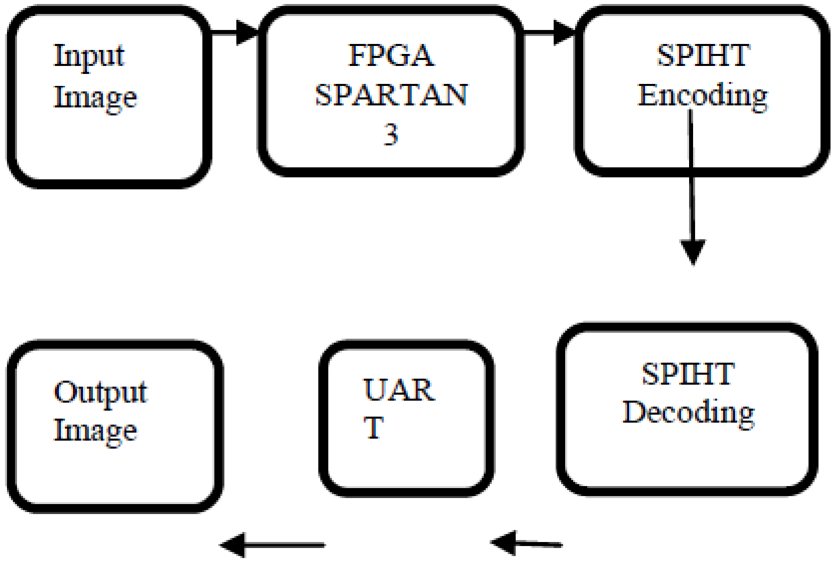

FIGURE 5 FPGA IMPLEMENTATION

Module 1: Conversion of image into Header file using GUI
Module 2: Hardware Custom logic- EDK
Module 3: Micro blaze Processor design - EDK
Module 4: Implementation in FPGA – EDK

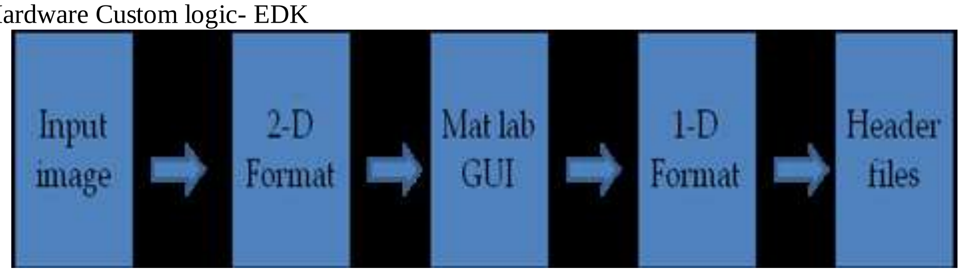

FIG 6 IMAGE CONVERTED TO HEADER FILE.

Using Matlab GUI, image file should be converted to a header file format. Then we add as an header file in our Impulse C code[9]

RESULTS

FIRST LEVEL DECOMPOSITION

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

SECOND LEVEL DECOMPOSITION

THIRD LEVEL DECOMPOSITION

CONSLUSION

In this paper we have developed a technique for wavelet transforms. We pointed out that this transform can be assigned to the encoder or the decoder and that it can hold compressed data. We provided an analysis for the case where both encoder and decoder are symmetric in terms of memory needs and complexity. We described spiht coding algorithm that can work with very low memory in combination with the line based transform, and showed that its performance can be competitive with state of the art image coders. To the best of our knowledge, our work is the first to propose a detailed implementation of a low memory wavelet image coder. A significant advantage by making a wavelet coder attractive both in terms of speed and memory needs. More improvements of our system especially interms of speed can be achieved by introducing a lattice factorization of the wavelet kernel or by using the lifting steps.

REFERENCES

1. Forchheimer R. (1999), Image coding and data compression, Linköping: Department of electrical engineering at Linköpings University.
2. Chui C. K. (1992), An introduction to wavelets, Boston, Academic Press, ISBN 0121745848

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

3. Sayood K. (2000), Introduction to data compression, Morgan Kaufmann Publrs, US, 2 revised edition, ISBN 1558605584.
4. Daubechies I., Barlaud M., Antonini M., Mathieu P. (1992), "Image coding using wavelet transform" in IEEE Transactions on image processing, Vol. 1, No. 2, pp. 205-220.
5. Brislawn C. M.. (1996), "Classification of nonexapnsive symmetric extension transforms for multi rate filter banks" in Applied and computational harmonic analysis, Vol. 3, pp. 337-357.
6. Azpiroz-Leehan J., Lerallut J.-F. (2000), "Selection of biorthogonal filters for image compression of MR images using wavelet packets" in Medcial engineering & physics, Vol. 22, pp. 225-243.
7. M. Vishwanath, R. Owens, and M. J. Irwin, "VLSI architectures for the discrete wavelet transform," IEEE Trans. Circuits Syst. II, Analog.Digit.SignalProcess. vol. 42, no. 5, pp. 305–316, May 1995
8. T. Vijayakumar α & S. Ramachandran σ"Design and FPGA Implementation of High Speed DWT-IDWT Architecture with Pipelined SPIHT Architecture for Image Compression"Global Journal of Computer Science and Technology: Volume 14 Issue 1 Version 1.0 Year 2014 Type: Double Blind Peer Reviewed International Research Journal Publisher: Global Journals Inc. (USA) Online ISSN: 0975-4172 & Print ISSN: 0975-4350
9. VenkataAnjaneyulu, P. Rama Krishna "FPGA Implementation Of DWT-SPIHT Algorithm For Image Compression"INTERNATIONAL JOURNAL OF TECHNOLOGY ENHANCEMENTS AND EMERGING ENGINEERING RESEARCH, VOL 2, ISSUE 3 20 ISSN 2347-4289 Copyright © 2014 IJTEE.