Chip Design of DWT for Image Compression

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Abstract – ***The wavelet analysis is used to divide the complete information of a digital image into the detailed sub images and approximated signals. The approximation values of the sub signal generally show the pixel values of an image. The basic idea of the wavelet transform is to represent any arbitrary function f as a superposition of wavelets. Any such superposition decomposes f into different scale levels, where each level is then further decomposed. Like Fourier Transform, which is the sum of all time signal f(t) multiplied by a complex exponential and the result of the transform are the Fourier coefficients. The continuous wavelet transform is defined as the sum overall time of signal multiplied by scaled, shifted version of wavelet function. The research paper focuses on the VHDL design and development of image compression algorithm Discrete Wavelet Transform (DWT). The work is based on the HAAR DWT, in which the image is divided into LL, LH, HL and HH band in first level of decomposition, further decomposition can take place with respect to each band. In the second level of decomposition the LL band is subdivided into LLLL, LLLH, LLHL and LLHH sub bands. The design is developed in Xilinx ISE software 14.1 and functionally simulated in Modelsim9.0 software.***

Key Words: *Discrete Wavelet Transform (DWT), Very High Speed Integrated Circuit Hardware Description Language (VHDL), Digital Image Processing (DIP).*

1. INTRODUCTION

Now a day's Medical science is growing very fast, hence each hospital needs to store high volume of information about the patients. And medical images are one of the most important data about patients. As a result hospitals have a high volume of images or information with them and require a huge space and transmission bandwidth to store these images or information. Most of the time transmission bandwidth is not sufficient in storing all the image data.

Image compression is the process of encoding the data using lesser bits or other information than un-encoded representation which make use of specific encoding schemes. Compression is mainly used to reduce the consumption of expensive memory, such as read only memory or hard disk space and transmission bandwidth (B.W). On the downside, compressed information must be de-compressed. For instance a Compression scheme for image may require expensive hardware for the image to be de-compressed must be fast enough to be viewed as its being decompressed (the option of decompressing the image fully before viewing it can be inconvenient, and requires storage memory for the de-compressed image).Hence the design of image compression schemes involves trade-offs among the various factors, including degree of Compression, the amount of distortion introduced if using a Lossy Compression scheme, and the computational resources required to compress and de-compressed the information [6, 18]. Data compression is the process of converting data files into smaller ones for higher efficiency of storage and transmission. Each compression algorithm has its corresponding decompression algorithm and it should reproduce the original one. An image compression scheme comes under two categories: - lossless and lossy compression. Lossless compression uses coding techniques to compress data while retaining all the information content. However, in this case the achieved file size reduction may be not sufficient for many applications. Lossy image compression, as its name implies, output image is the result of loss of some information content while the file size reduction can be made more significant than the lossless image compression. Since most digital images are intended for human, much research is nowadays focused on lossy image compressions that minimizes visual distortion and possibly obtain visually lossless results. Image Compression is the application of Data compression on digital images. Image Compression is reducing the size of a graphic file without degrading the quality of the image or data to an acceptable level. The minimizations in image size allow more images to be stored in a given amount of memory storage space. It also minimizes the time required for images or data to be transmit over the Internet or downloaded from Web page. This would imply the need for a compression scheme that would give a very high compression ratio usually comes with a price. This refers

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to quality of the image. Given a particular compression ratio, the quality of the image constructed using the SPHIT algorithm make the work more better way even though the problems come into the picture is the issue of energy constraints. While compressing and transmitting an image, if the coefficients to be transmitted are of very large magnitude then the more resources would be required for transmission. This is taken care by employing energy efficient compression. But again medical images cannot afford the loss of the important details for the sake of meeting battery constraints for telemedicine. This is also taken care in this work and the regions of diagnostic importance are undisturbed in course of achieving energy efficiency. Another important characteristic, which is often the criteria or even the referred base of diagnosis in medical images, is the texture of the different regions within the image. Cryptography and image compression can be integrated in a single chip. Cryptography has become an essential tool in transmission of information. Cryptography is the central part of several fields: information security and related issues, particularly, authentication, and access control. Cryptography encompasses a large number of algorithms which are used in building secure applications.

2. DISCRETE WAVELET TRANSFORM (DWT)

Image transforms are used in image processing and image analysis. Image transform is basically a representation of an image. Wavelet transform is the most popular transform of image processing. Wavelet analysis can be used divided the information of an image into approximation and detailed sub image signal. The approximation sub signal shows the generally pixel value of image. It has three detailed sub signal show the horizontal, vertical and diagonal details. The details can be set to zero without significantly changing the picture, if detail is very small. If the number of zeroes is greater than the compression ratio is also high. There is two types of wavelet is used in image analysis and compression technique. First type of wavelet is continues wavelet transform and second one is discrete wavelet transform. The wavelet analysis is computed with the help of filter bank. Filter bank is a combination of high pass and low pass filters. High pass filter kept high frequency information and lost low frequency information. On the other side, low pass filter kept low frequency information and lost high frequency information.The image is high and low-pass filtered along the rows. Results of each filter are down-sampled by two. The two sub-signals correspond to the high and low frequency components along the rows, each having a size N by N/2. Each of the sub-band is then again high and low-pass filtered, but now along the column data and the results are again down-sampled by two.

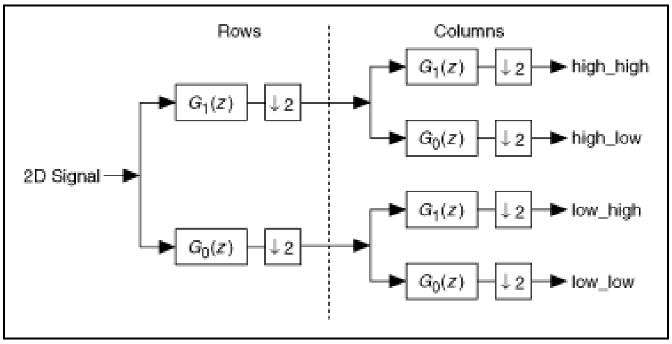

Fig-1:DWT row and column processing

Hence, the original data or image is splited into four sub-images each of size N/2 by N/2 and contains information from different frequency components [9, 12]. Fig.1 shows the block wise representation of decomposition step.

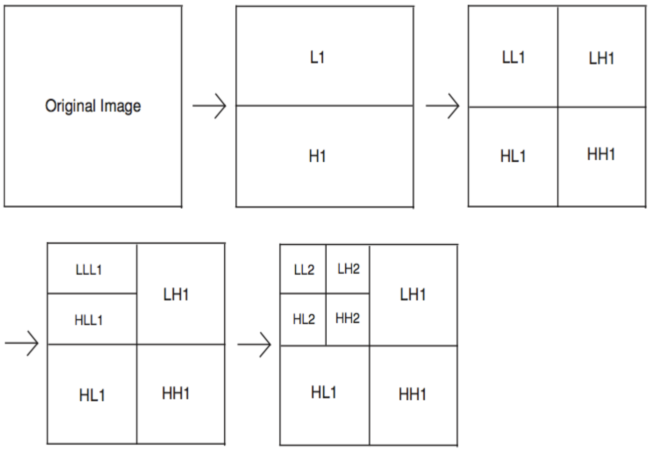

Fig- 2: HAAR DWT Two Level decomposition

The LL sub-band obtained by Low-pass filtering both the rows and columns, contains a rough description of the image and hence called the approximation sub-band. The HH Sub-band is high-pass filtered in both directions, contains the high-frequency components along the diagonals. The HL and LH sub-band result from low-pass filtering in one direction and high pass filtering in other direction. LH contains mostly the vertical detail information, which corresponds to horizontal edges. HL represents the horizontal detail information from the vertical edges[12]. The sub-bands HL, LH and HH are called the detailed sub-bands since they add high-frequency details to the approximation image.

2.1 Decomposition Process in DWT

The decomposition of DWT is shown in Fig. 3 that corresponds to the composition technique in four bands. It accepts the size of 256 x 256 as size of original image .The four sub-images or sub-bands are up-sampled and then filtered with the corresponding inverse filters along the columns [12, 16, 18]. The results size of LL, LH, HL and HH band is 128 x 128. The result of the last step is added together and the original image is retained, with no information loss and the sub bands size is 64 x 64 with respect to LLLL, LLLH, LLHL and LLHH.

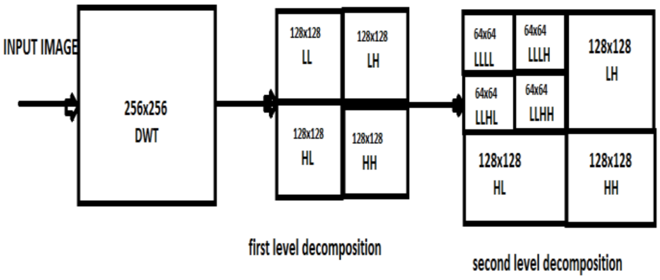

Fig-3: HAAR DWT with pixels decomposition

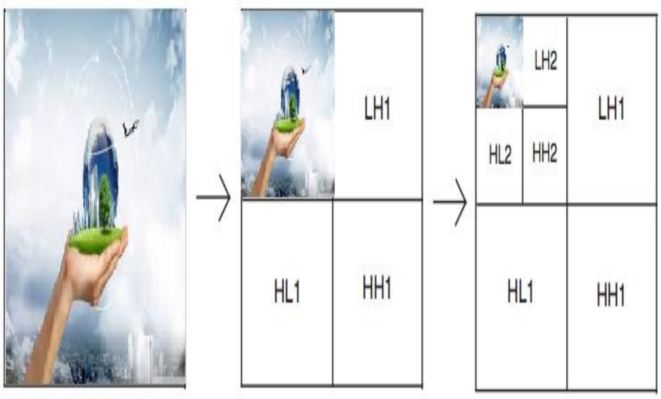

Fig- 4: Example of DWT

In first level of decomposition the input image is decomposed in four bands as shown, each block; pixel value is divided 2; in second level of decomposition again band is divided in sub bands.

3. TOOLS DESCRIPTION

The tools used for the design are Xilinx ISE 14.1 and Modelsim 10.1b

Xilinx ISE 14.1:Xilinx [7] [8] has been a semiconductor industry leader at the forefront of technology, market and business achievement. It is a tool to design the IC and to view their RTL (Register Transfer Level) schematic .It is a tool to test the code on FPGA environment and the values of all parameters details required to implement the Chip. The detail of the synthesized results includes the hardware details, utilization of hardware parameters, memory utilization and timing information.Device utilization report gives the percentage utilization [13] of device hardware for the chip implementation. Device hardware includes No of slices, No of flip flops, No of input LUTs, No. of bounded IOBs, and No of gated clocks (GCLKs) used in the implementation of design. Timing [13] details provides the information of delay, minimum period, maximum frequency, minimum input arrival time before clock and maximum output required time after clock

Modelsim 10.1 B: Mentor Graphics [9] was the first to combine single kernel simulator (SKS) technology with a unified debug environment for Verilog HDL, VHDL, and System C. The simulation and synthesis combination of industry-leading and native SKS performance with the best integrated debug and analysis environment make Modelsim the simulator of choice for both ASIC and FPGA design. The design platform and standards support in the industry make it easy to adopt in the majority of process and tool flows.

4. RESULTS

The Modelsim results of DWT is shown in fig. 5 in which an image of 16 x 16 with values is given Input is {27,6,13,10,7,7,6,4,4,4,4,3,2,2,20} and the results corresponds to the values are LL={27,6,7,7}, LH={13,10,6,4}, HL={4,4,2,2}, HH={4,3,2,0}, LLLL=27, LLLH=6, LLHL=7, LLHH=7, obtained by the functional simulation of DWT. The RTL view of the corresponding design is shown in fig. 6 and the description of the pins is listed in the table 1. The functional simulation depends on the logic inputs reset and clock which are synchronized with each other.

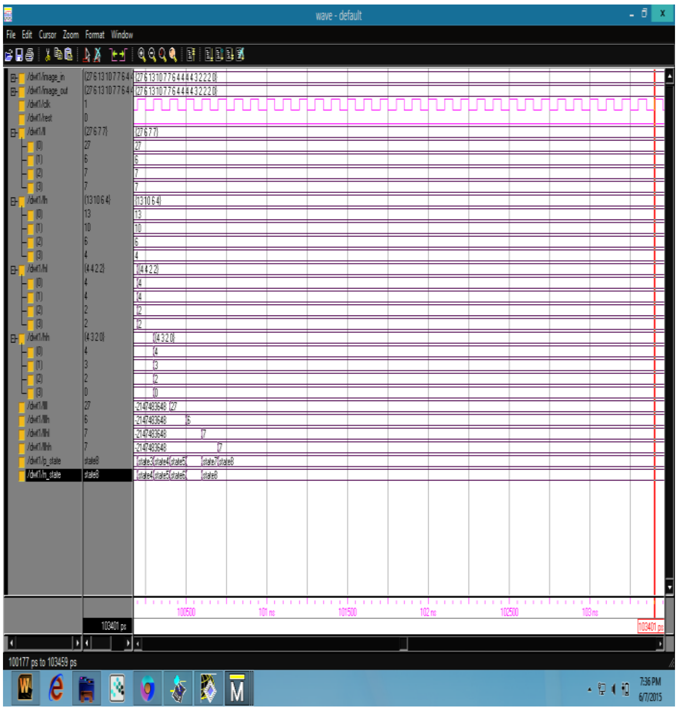

Fig- 5: Modelsim simulation of DWT

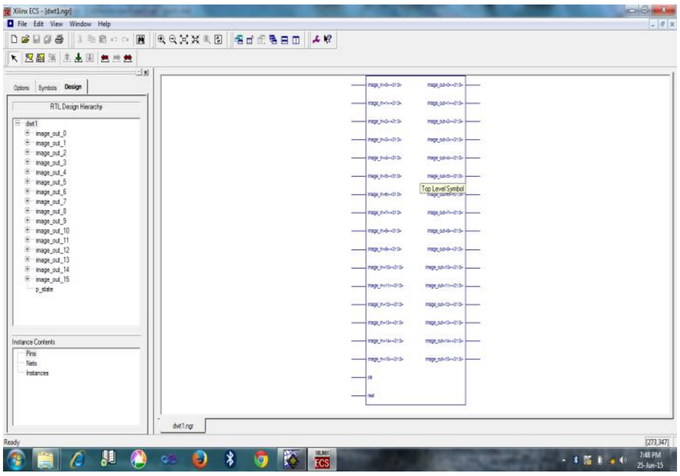

Fig- 6: RTL view of 2D DWT

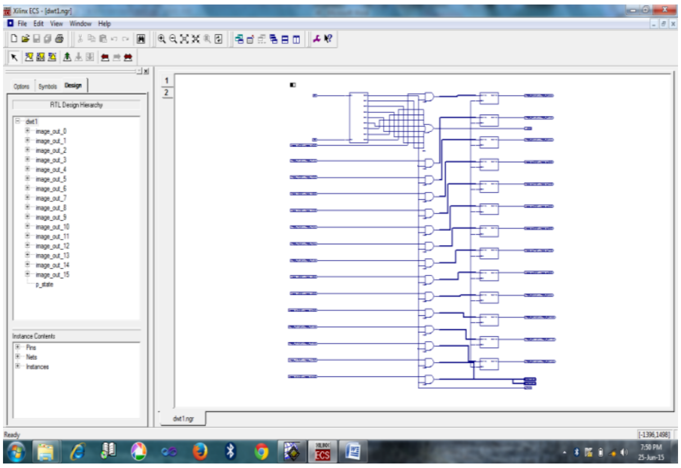

Fig-7: Internal diagram of DWT

The RTL register Transfer Level view of the DWT is shown in fig. 6 and its internal schematic is shown in fig. 7.

Table-1: Pin Details

Pins	Details
Image_in(0) to Image_in(15)	Input values of pixels for the image size 16 x 16
Image_out(0) to Image_out(15)	Output values of pixels for the image size 16 x 16
clk	Image input to the sequential logic for image compression provide clock as default input
Reset	Input to reset the system or zero and synchronized with the clock default input

5. CONCLUSIONS

The simulation of the HAAR DWT is carried out successfully in Xilinx 14.1 software. HAAR DWT is a popular transform for image compression. The developed design for image compression is tested for several test cases and functional checked on the Modelsim software successfully. 2D Discrete Wavelet Transform (2D DWT) is used in image processing as a powerful tool solving to image analysis, denoising, image segmentation and other. 2D DWT can be applied as a convolution of a selected wavelet function with an original image or it can be seen as a set of two matrices of filters, row and column one. Using a separability property of DWT, the first part of decomposition consists of an application of row filters to the original image. In future, it is proposed to use the concept of image compression integrated with cryptographic schemes of encryption and decryption over a particular network [1,2].

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