Design and Implementation of 2D-Dwt for Image Compression Using VLSI Architecture

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Abstract: This paper studies the implementation of VLSI Architecture of image compression system using wavelet transform, discrete wavelet transform is the most widely used image compression technique and it is the most efficient algorithm used in JPEG image compression. An architecture that performs both forward and inverse lifting-based discrete wavelet transform is proposed Conventional method requires more memory, area and power; lifting scheme is used as an enhanced method. Architecture of the DWT which is a powerful image compression algorithm is implemented using lifting based approach. This architecture results in reduced memory referencing, low power requirement, low latency and high throughput. The Inverse Discrete Wavelet Transform (IDWT) is also obtained in a similar way to get back the image matrix. The design can be used for both lossy and lossless compression. To reduce the complexities of the design, linear algebra view of DWT and IDWT has been used.

Keywords: Xilinx Tool, DWT (Discrete wavelet transform), MATLAB Tool, Lifting scheme, Image Processing.

I. INTRODUCTION

The image undergoes preprocessing were resizing and conversion of gray to color is done and the gray scale image is forward wave lifted to get only the decomposed image then MATLAB generated LL band image is converted into hexadecimal values and written in a text file and the same text file is read by the Xilinx tool in order to wave lift the image and the corresponding inverse is also obtained and saved in another text file and that file is read by MATLAB to show outputs of Xilinx compressed image.
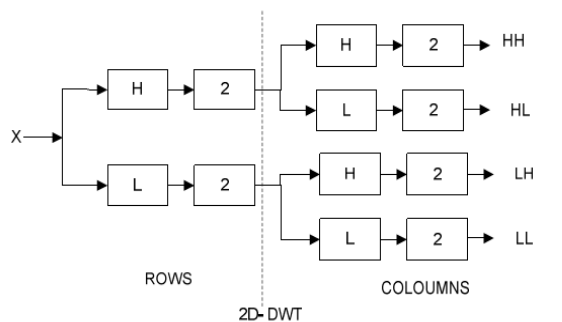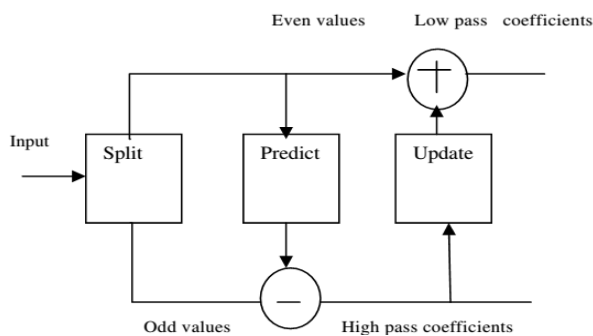
The figure shows the decomposition of an image using DWT architecture were it has filters that gives the output of LL frequency band that has higher timing resolution in other words it has large information
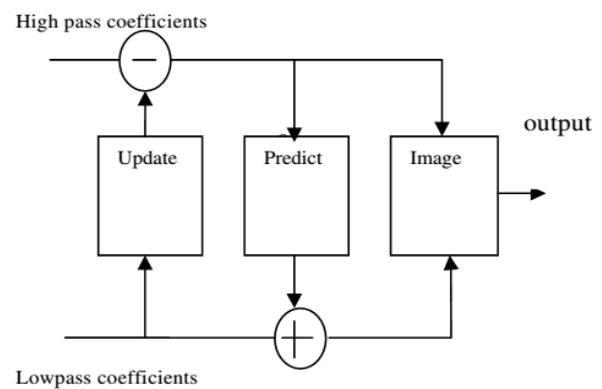

Fig 3: Inverse lifting scheme

Fig 1: Preprocessing of DWT

The **lifting scheme** is a technique for both designing wavelets and performing the discrete wavelet transform. Actually it is worthwhile to merge these steps and design the wavelet filters while performing the wavelet transform. This is then called the second generation wavelet transform. The technique was introduced by Wim Sweldens.

A **wavelet** is a wave-like oscillation with an amplitude that begins at zero, increases, and then decreases back to zero. It can typically be visualized as a "brief oscillation" like one might see recorded by a seismograph or heart monitor. Generally, wavelets are purposefully crafted to have specific properties that make them useful for signal processing. Wavelets can be combined, using a "reverse,

Fig 2: Forward lifting scheme

shift, multiply and integrate" technique called convolution, with portions of a known signal to extract information from the unknown signal.
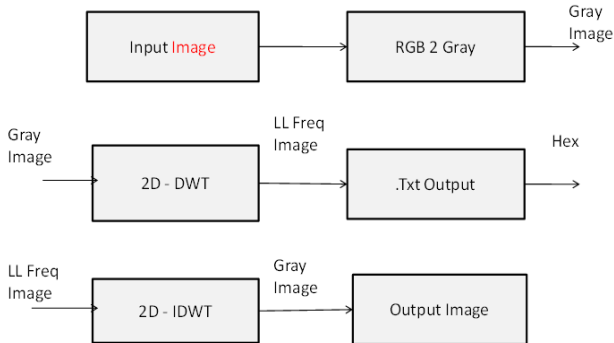
Block Diagram

Fig 4: Block Diagram.

The paper has two phases one is the convolution method and the other one the proposed method and the Report mainly deals with the convolution method that is built using MATLAB flow, as in the block diagram input color image is given for pre-processing where the resizing and the conversion RGB to Gray is done then the process of 2D – DWT is done where the decomposition of gray scale image is converted into four frequency sub bands and the lower frequency sub bands have higher time decision and the LL frequency sub band is converted a d stored in .txt file and the inverse DWT is applied to reconstruct the image.

Applications of wavelet transform
Generally, an approximation to DWT is used for data compression if a signal is already sampled, and the CWT for signal analysis. Thus, DWT approximation is commonly used in engineering and computer science, and the CWT in scientific research.

Like some other transforms, wavelet transforms can be used to transform data, and then encode the transformed data, resulting in effective compression. For example, JPEG 2000 is an image compression standard that uses bi orthogonal wavelets. This means that although the frame is over complete, it is a tight frame (see types of frames of a vector space), and the same frame functions (except for conjugation in the case of complex wavelets) are used for both analysis and synthesis, i.e., in both the forward and inverse transform. For details see wavelet compression.
A related use is for smoothing/denoising data based on wavelet coefficient thresholding, also called wavelet shrinkage. By adaptively thresholding the wavelet coefficients that correspond to undesired frequency components smoothing and/or denoising operations can be performed.

II. CONVENTIONAL METHOD

The conventional method being MATLAB the results of forward and inverse constructed images are shown in the figure 5. Here in the below images we can see that the gray image and inverse wave lifted images are same.
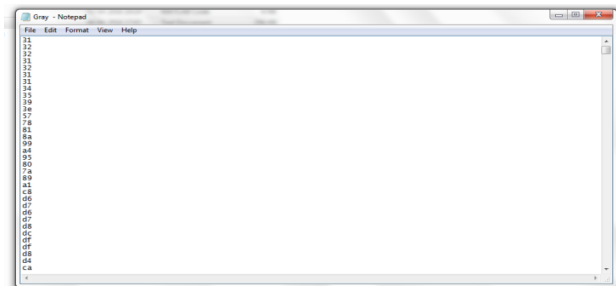

Fig 5: MATLAB Images

Fig 6: Output in Text File.

The text file sizes will be very less when compared to gray image.

III. PROPOSED METHOD

In the proposed architecture the main theme is by using FPGA architecture and the same gray input is taken as input for Xilinx tool in order to ensure the same output and the txt file is read in Xilinx and the wave lift is applied to get the DWT compressed image and inverse to get original image. the results are as shown below
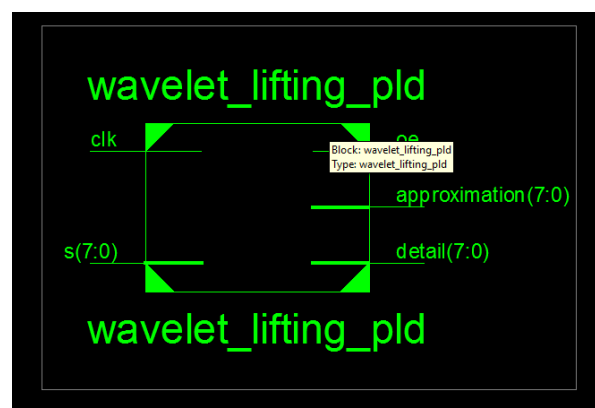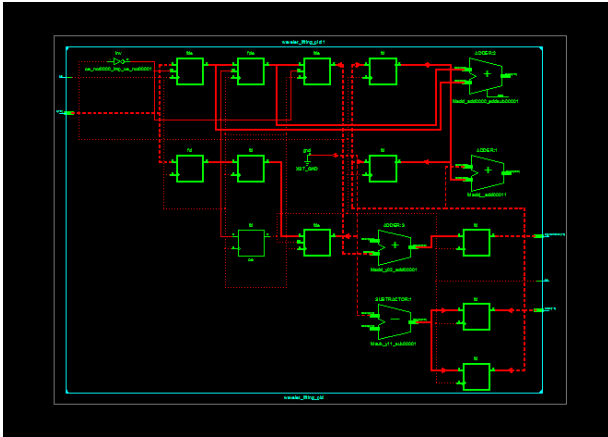

Fig 7: Block Diagram
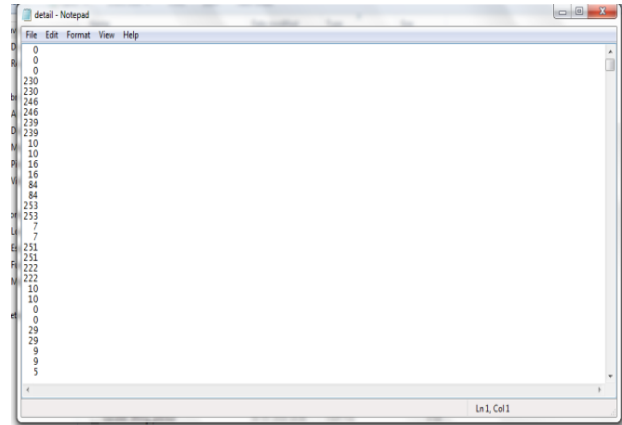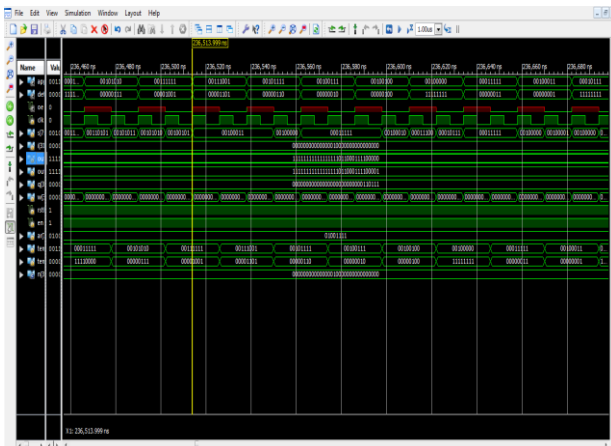
Fig 8: RTL Diagram

Fig 12: Detail Values

Fig 9: Output Waveforms in Xilinx

The Xilinx output passes some data to the approx and det files and those files are read in MATLAB to get the compression results of Xilinx tool.

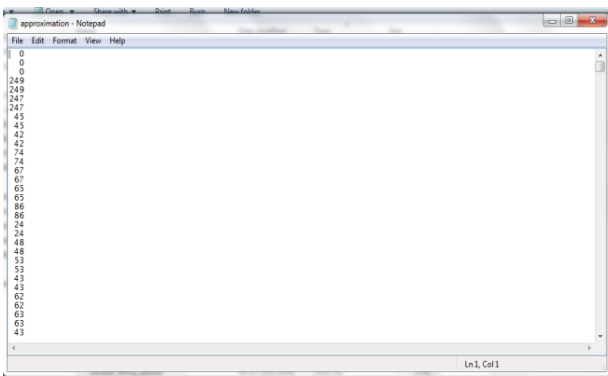Fig 10: Xilinx Wave lifted and Inverse Images

Fig 11: Approximation Values

Xilinx outputs has some distortion in the images because the FPGA takes the values as floating points but the processing will be in real time and also the speed of execution will be more.

V. CONCLUSION

Here the input image is read in MATLAB environment then its approximate and details coefficients are achieved by different decomposition levels .Compression ratio is also achieved which is shown in MATLAB editor window. 2D DWT is done; we can choose the decomposition level. Care should be taken that the recovered image should match the original input image. This code will work for both lossy and lossless images, so we can have the input image like satellite image, medical image, biometrics images .For hardware realization of the compression we need to convert the it from MATLAB environment to VHDL environment. This will give us the VLSI approach to design the compression of the image. For the same image in matrix form VHDL code is written to get the VLSI architecture of the compression technique. After generating the bit file which can also be implemented using FPGA Devices.

In future scope we can try the same for real time operations in multimedia applications.RTL view is also observed first before final design of the product. Xilinx system generator tool is also used for synthesizing the design. We can also use the Verilog HDL for hardware realization of the compression techniques. This will work for both lossless and lossy image compression techniques.

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