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HIGH LEVEL SYNTHESIS OF A 2D-DWT SYSTEM ARCHITECTURE FOR JPEG 2000 USING FPGAs

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ABSTRACT

Despite all the advantages of JPEG compression schemes based on DCT namely simplicity, satisfactory performance, and availability of special purpose hardware for implementation this method degrades the quality of the image. DWT offer better subjective image quality compared to Discrete Cosine Transform (DCT)-based compressed images under low bit rates, due to DWT's inherent scalability and better de-correlation properties. DWT has traditionally been implemented by convolution or FIR filter bank structures. Such implementations require both a large number of arithmetic computations and a large storage features that doesn't support high speed or low power image or video processing applications.So a scheme called "Lifting Based DWT" is proposed which requires far fewer computations than the previous methods.

Keywords: Image compression, DWT, JPEG2000, FPGA.

I. INTRODUCTION

JPEG and JPEG2000 codec are pervasive in so many applications in our world today. Consequently, standards for the efficient representation and interchange of digital images are essential. However, digital images and videos are still demanding in terms of storage space and transmission bandwidth. Lossy compression is necessary to bring these demands down to manageable level, but it introduces various types of artifacts, such as blockiness, blur, ringing, noise etc. Current hardware implementations of jpeg and jpeg2000 codec mostly target maximizing speed performance so as to achieve real time behavior even when compressing image with very high resolutions. For the encoder comparison we compress a set of 29 test images with two JPEG encoders and three JPEG2000 encoders at various compression ratios. This paper proposes a JPEG encoder that targets minimal FPGA resource usage without compromising encoded image quality.

II. ARCHITECTURE

The main feature of this Lifting based DWT scheme is to break up the high pass and low pass filters into a sequence of upper and lower triangular matrices and convert the filter implementation into banded matrix multiplications.The

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proposed architecture computes multi level DWT for both the forward and the inverse transforms one level at a time in a row column fashion.

Discrete Wavelet Transform

Discrete wavelet transform (DWT), which transforms a discrete time signal to a discrete wavelet representation.It converts an input series x_0, x_1, ..x_m, into one high-pass wavelet coefficient series and one low-pass wavelet coefficient series .

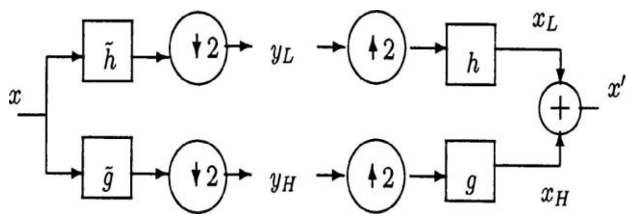

Fig1: Discrete wavelet transform

2D DWT IMPLEMENTATION

Let h(z)' and g(z)' low pass and high pass analysis filters and let h(z) and g(z) be low pass and high pass synthesis filter. Then 2D DWT is implemented as follows:

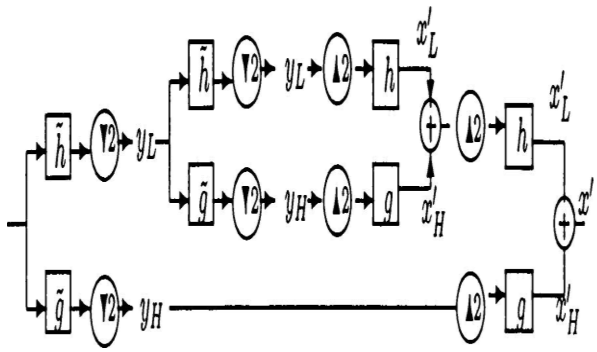

Fig2: DWT Implementation

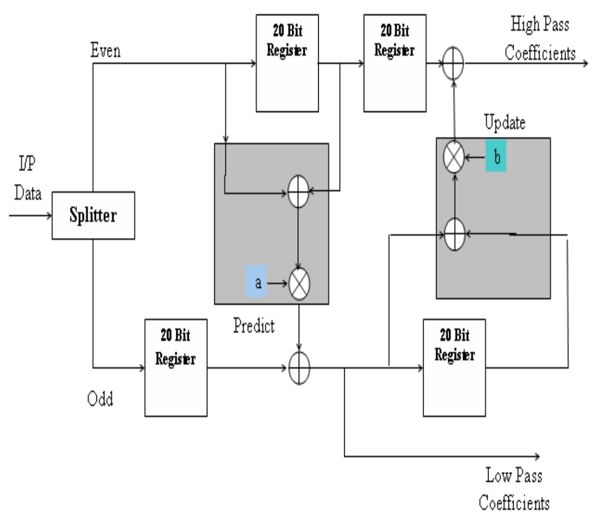

Fig3: Architecture of 2-D (5, 3) Discrete Wavelet Transform

DECOMPOSITION IN 2D DWT

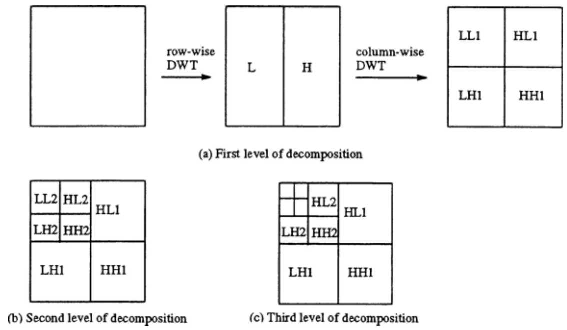

Fig4:Decomposition in 2D DWT

Then the corresponding poly-phase matrices are defined as:

$$\tilde{P}(z) = \begin{bmatrix} \tilde{h}_e(z) & h_o(z) \\ \tilde{g}_e(z) & g_o(z) \end{bmatrix}$$

$$P(z) = \begin{bmatrix} h_e(z) & g_e(z) \\ h_o(z) & g_o(z) \end{bmatrix}$$

When the determinant of P(z) is unity, the synthesisfilter pair (h, g) and the analysis filter pair (˜h, ˜ g), are both complementary.

$$P(z) = \begin{bmatrix} h_e(z) & g_e(z) \\ h_o(z) & g_o(z) \end{bmatrix} = \prod_{i=1}^{m} \underbrace{\begin{bmatrix} 1 & s_i(z) \\ 0 & 1 \end{bmatrix}}_{\text{primal lifting}} \underbrace{\begin{bmatrix} 1 & 0 \\ t_i(z) & 1 \end{bmatrix}}_{\text{dual lifting}} \underbrace{\begin{bmatrix} K & 0 \\ 0 & 1/K \end{bmatrix}}_{\text{normalization}}$$

III. IMPLEMENTATION

The two types of lifting schemes are shown in the above figure. Scheme 1 P(z) which corresponds to the factorization consists of three steps. Predict step, where the even samples are multiplied by the time domain equivalent of t(z) and are added to the odd samples. Update step, where updated odd samples are multiplied by the time domain equivalent of s(z) and are added to the even samples. Scaling step, where the even samples are multiplied by 1/k and odd samples by k.

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LIFTING SCHEME

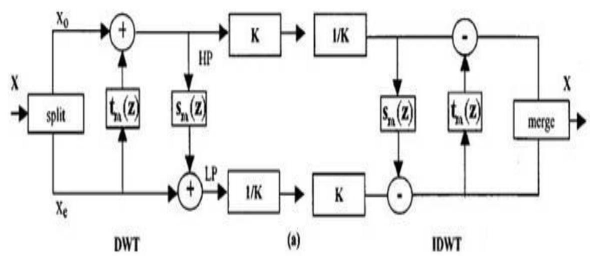

Fig5: Lifting Scheme

The inverse DWT is obtained by traversing in the reverse direction changing the factor k to 1/k and reversing the signs of the co-efficients t(z) and s(z).The basic idea of lifting is the following: If a pair of filters (h, g) is complementary, that is it allows for perfect reconstruction, then for every filter the pair(h', g) with h'(z)=h(z)+s(z^2).g(z) allows for perfect reconstruction.

DEVICE UTILIZATION SUMMARY OF DWT BLOCK

top_idwt Project Status (04/02/2013 - 14:43:18)			
Project File:	idwtnew.xise	Parser Errors:	No Errors
Module Name:	top_idwt	Implementation State:	Synthesized
Target Device:	xc3s500e-5fg320	•Errors:	No Errors
Product Version:	ISE 12.2	•Warnings:	3 Warnings (3 new)
Design Goal:	Balanced	•Routing Results:	
Design Strategy:	Xilinx Default (unlocked)	•Timing Constraints:	
Environment:	System Settings	•Final Timing Score:	

Device Utilization Summary (estimated values)			[-]
Logic Utilization	Used	Available	Utilization
Number of Slices	769	4656	16%
Number of Slice Flip Flops	909	9312	9%
Number of 4 input LUTs	1477	9312	15%
Number of bonded IOBs	109	232	46%
Number of GCLKs	1	24	4%

Detailed Reports					[-]
Report Name	Status	Generated	Errors	Warnings	Infos
Synthesis Report	Current	Tue Apr 2 14:43:16 2013	0	3 Warnings (3 new)	60 Infos (60 new)
Translation Report					

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IV. RESULTS

SIMULATION RESULTS

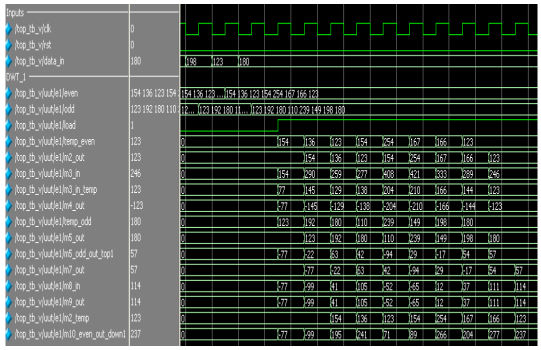

Figure 6: Simulation Result of DWT-1 Block with Both High and Low Pass coefficients

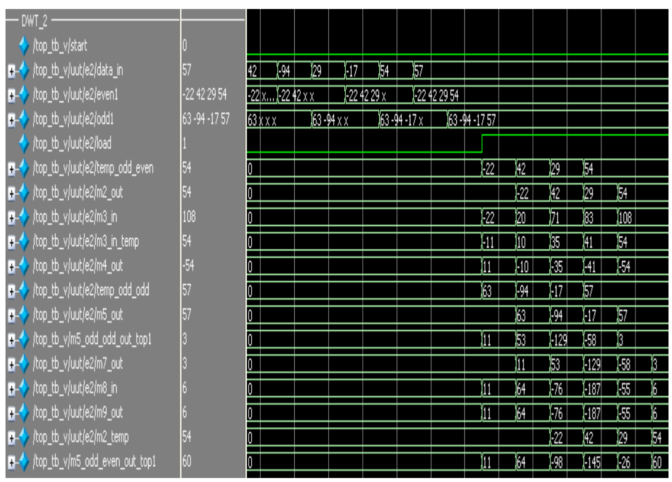

Figure 7: Simulation Result of DWT-2 Block with Both High and Low Pass Coefficients

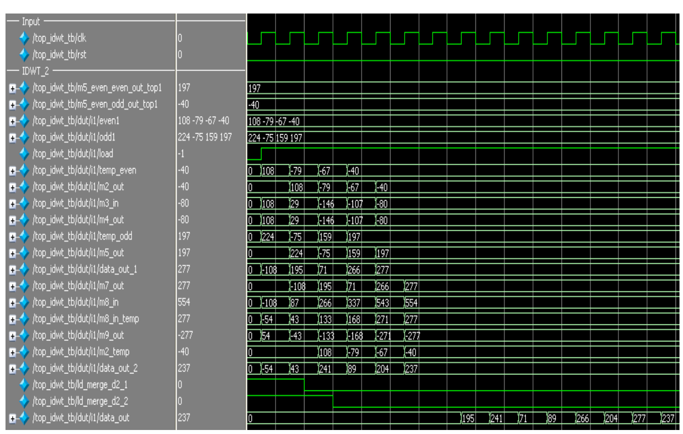

Figure 8: Simulation Result of IDWT-2 Block

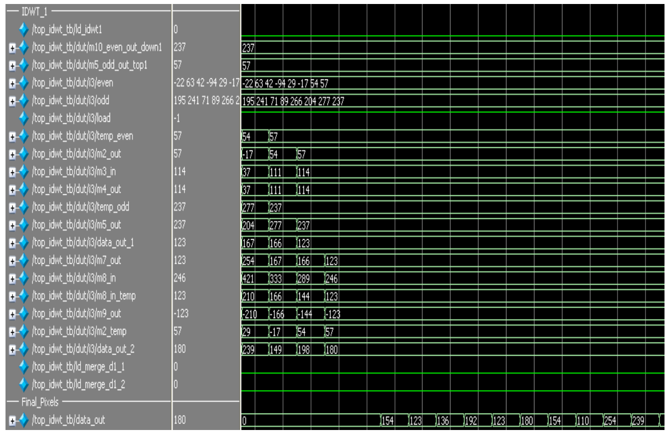

Figure 9: Simulation Result of IDWT-1 Block with Final Pixel Values

V. CONCLUSION

Wavelet-based coding provides substantial improvement in picture quality at low bit rates because of overlapping basis functions and better energy compaction property of wavelet transforms.Wavelet-based coders facilitate progressive transmission of images thereby allowing variable bit rates. Basically the medical images need more accuracy without loosing of information. The Discrete Wavelet Transform (DWT) was based on time-scale representation, which provides efficient multi-resolution. Hence it has been analyzed that the Discrete wavelet transform (DWT) and inverse discrete wavelet (IDWT) transform operates at a maximum clock frequency of 113.841 MHz and 80.290 MHz respectively.

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