VLSI Implementation of Reversible Watermarking Algorithm

Meghal Patel
VLSI & Embedded System Design
Gujarat Technological University PG School
Ahmedabad, India
Meghal.patel1374@gmail.com

Mrs. Mousami Turuk
Assistant Professor
PICT
Pune, India
mpturuk@pict.edu

Jaya Virwani
VLSI and Embedded System Design
Ahmedabad, India
jayavirwani.53@gmail.com

Abstract — This paper presents VLSI design approach and implementation of Lifting based Reversible Watermarking Algorithm. 5 by 3 Lifting based Discrete Wavelet Transform based image watermarking algorithm is proposed. It is attractive algorithm because of easier understanding and implement. Main feature of Lifting based scheme is that all constructions are derived in the spatial domain. Therefore it does not require complex mathematical calculations that are required in traditional method. This algorithm is mainly applicable in Military application as well as Medical application where reconstruction of original image and watermarking data (or image) is essential from the watermarked image after serving intended purpose. In this algorithm, image is decomposed into four sub bands LL, LH, HL, and HH using Lifting based DWT Algorithm. Then watermarking data (or image) is embedded into any of three high frequency sub bands. The interesting point of this algorithm is that original image can be exactly restored from the watermarked image. The architecture of Lifting based DWT Algorithm has been coded in verilog HDL on Xilinx platform and the target FPGA device used is Virtex-IV family.

Keywords- *Lifting Based Scheme, VLSI architectures, Simulation Results and RTL Views.*

*****

I. INTRODUCTION

Digital watermarking was first appeared in 1993, when Tirkel presented two watermarking techniques to hide the watermark data in the images. Digital watermarking is used for data authentication and copyright protection to the digital media.

Digital watermarking is the technique of embedding data, image, signal or secret information into the digital media such as image, audio and video. Later the information which is embedded into digital media is detected and extracted. Digital watermarking is used for various applications like Proof of Ownership, Data Hiding, Authentication, Copyright Protection etc.

Digital watermarking is broadly classified depending on the type of signal like audio watermarking, image watermarking, video watermarking, and database watermarking etc. The present work is focused on image watermarking.

Digital watermarking is classified into various categories based on different characteristics [2]. Digital watermarking is mainly classified into two domains according to embedding domain which is spatial domain and frequency domain [2]. In spatial domain, directly operates on pixel values of original image whereas in frequency domain, pixel values are transformed into another domain by applying appropriate watermarking transform technique. Then watermark is embedded by modifying coefficients of watermarking technique.

Various Reversible Watermarking techniques have been proposed [2]-[3]. Some of popular techniques of reversible watermarking are listed below.

i. Difference Expansion
ii. Histogram bin Shifting,
iii. Data hiding using Integer Wavelet Transform,
iv. iv)Contrast Mapping, and
v. Integer Discrete Cosine Transform

There are more advantages of DWT algorithm over another watermarking algorithm [2]. It has main advantage is that it allows good localization both in time and spatial frequency domain.

In Digital Signal Processing Discrete Wavelet Transformation (DWT) plays major role in last decade. It has wide application in Image and Signal Processing. The advantages of the wavelet transform over other transforms, such as the Fourier transform, are now well recognized. Definition of DWT by Mallat [1] provided possibility of its digitally hardware or software implementation.

There are two methods for implementing DWT algorithm first one is Filter Bank Structure and second one is Lifting Based Scheme. In Filter Bank Structure, DWT contains two FIR (finite impulse response) filters. Hardware implementation of filter is complicated and increases cost of hardware. It requires large number of arithmetic computations and needs large memory for storage.

The New Scheme named lifting scheme is introduced by Sweden's based on a spatial construction of the second generation wavelet and a very versatile scheme for its factorization has been suggested in Sweden's [4]. It is a technique for both designing wavelets and performing the discrete wavelet transform. This is then called the second generation wavelet transform. The technique was introduced by Wim Sweldens. The wavelet Lifting Scheme is a method for decomposing wavelet transforms into a set of stages. The discrete wavelet transform applies several filters separately to the same signal. In contrast to that, for the lifting scheme the signal is divided like a zipper. Then a series of convolution-accumulate operations across the divided signals are applied. The temporary arrays are not needed for calculating its steps with fewer computations; this becomes advantage over the other. We use the lifting coefficients to represent the discrete wavelet transform.

The synopsis of the paper is as follows: In section II, we discussed Lifting based scheme. In section III, we present sample example. In section IV, we present Architecture of DWT and IDWT. Section V, holds the simulated result and RTL Diagram of DWT and IDWT. Finally, concluded in section VI.

II. PROPOSED WORK

Lifting wavelet transform scheme consist of three steps given in [5]:

1) Split step:
Here the signal is split into even and odd points, because the maximum correlation between adjacent pixels can be utilized for the next predict step. For each pair of given input samples x (n) split into even x (2n) and odd coefficients x (2n+1).Where the input samples are split into two even and odd samples by the time domain.

2) Predict step:
The even samples are multiplied by the predict factor (α). Then multiplied values are added to the odd samples to generate the low frequency component.

3) Update step:
The low frequency component generated by the predict step are multiplied by the update factor (β). Then the multiplied values are added to the even samples to get the high frequency component.

The inverse transform is also same as forward which is easily done by exchanging the sign of the predict step and the update step and apply all operations in reverse order as shown in Fig.2. The implementation of lifting based inverse transform (IDWT) is simple and it involves order of operations in DWT to be reversed. Hence the same resources can be reused to define a general programmable architecture for forward and inverse DWT [7].

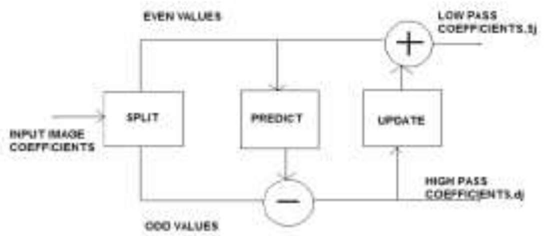

Figure 1: Block Diagram of Forward Lifting Scheme.

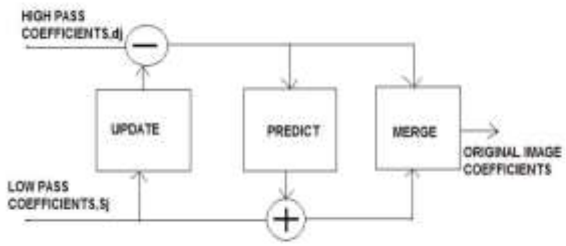

Figure 2: Block Diagram of Inverse Lifting IDWT

Equations for DWT

1. Splitting Step:

ISSN: 2321-8169
2894 - 2897

$d_i^0 = x_{2i+1}$……………………………….(1)
$s_i^0 = x_{2i}$…………..…………………….(2)

2. Lifting Steps:

$d_i^1 = d_i^0 + \alpha (s_i^0 + s_{i+1}^0)$….(predictor) (3)
$s_i^1 = s_i^0 + \beta (d_{i-1}^1 + d_i^1)$……(updater) (4)

Value of $\alpha = -1/2$ and $\beta = 1/4$.

In practice, some values are not available in Lifting based scheme computation.
For example,

$$d_0 \text{ and } S_{2^{n-1}+1}$$

For sake of simplicity, we equate such values to 0.

$$d_0 = 0 \text{ and } S_{2^{n-1}+1} = 0$$

III. DWT-IDWT ARCHITECTURE

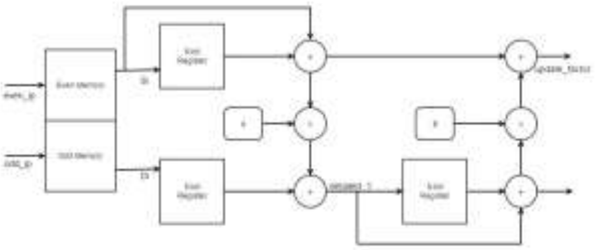

Figure 3: DWT Architecture

Figure 3 shows the detailed block diagram of DWT. Data coming to the DWT module from memory module will be split into even and odd samples. Even samples of picture will be given to Si, while odd samples will be given to Di. Si is added with the previous values of Si and further given to the multiplier block and it is multiplied with the constant α. The product of multiplier is truncated to 8-bits and it is added with Di values giving sum as detailed_1.

Thus the sum obtained by this phase is the outputs of predictor block; these are further given to updater block. In Updater block detailed_1 is added with the previous values of detailed_1, giving sum as detail_sum and addition is multiplied with constant β. The product obtained is again truncated to 8-bits and added with Si giving sum as update_factor. Here completes the stage one and this stage is giving output detailed_1 and update_facor. Simulation results obtained by implementing this hardware in Xilinx are shown in chapter V.

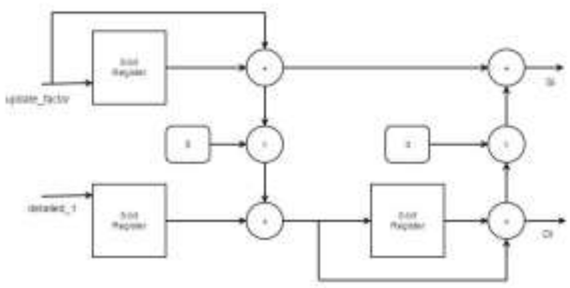

Figure 4: Detailed Block Diagram of IDWT

Figure 4 shows the functional block diagram of IDWT. Outputs of DWT detailed_1 and update_factor are stored into memory module. update_factor is added with the previous values of update_factor and further given to the multiplier block and it is multiplied with the constant β. The product of multiplier is truncated to 8-bits and it is added with detailed_1 values giving sum as di_sum. di_sum is added with its previous values of di_sum,giving sum as Di and addition is multiplied with constant α. The product obtained is again truncated to 8-bits and added with Di giving sum as Si. Here completes the stage one and this stage is giving output as Si and Di. Simulation results obtained by implementing this hardware in Xilinx are shown in chapter V.

IV. FPGA IMPLEMENTATION

A). Simulation Result.

Figure 5:- Simulation result of DWT

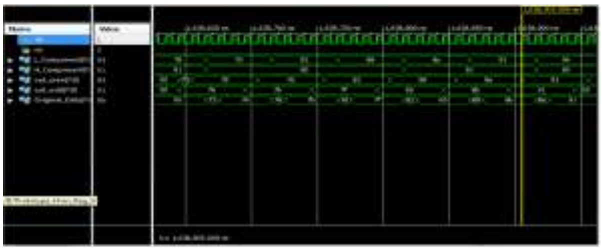

Figure 6:- Simulation result of DWT

ISSN: 2321-8169
2894 - 2897

B). RTL Views.

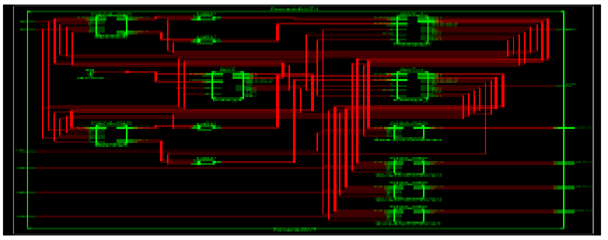

Figure 7:-RTL Schematic of 2D-DWT

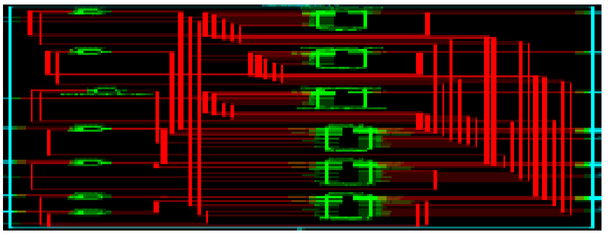

Figure 8:-RTL Schematic of 2D-IDWT

V. CONCLUSION

The reversible watermarking research is progressing very fast and various researchers from various fields are focusing to develop robust watermarking schemes. Despite of the efforts taken during last few years towards developing effective watermarking scheme, none of the techniques is robust to all possible attacks and image processing operations.

DWT is attractive transform because it can be used as a computationally efficient version of frequencymodels for HVS (Human Visual System). The wavelet based reversible watermarking is widely used today.

This paper analyses approach to wavelet based image watermarking in detail. Also, it reviews the VLSI implementation of reversible DWT Algorithm which will enable high scalability of the architecture which will be achieved through reducing the mathematical complexity and processing elements to match the desired solution.

ACKNOWLEDGMENT

I would like to express my deepest appreciation to all those who provided me the possibility to complete this paper. A special gratitude I give to my guide Mrs. Mousami Turuk and course coordinator Mr. Suresh Sikka whose contribution in stimulating suggestions and encouragement helped me to coordinate my seminar especially in writing this paper.

REFERENCES

[1]. S. Mallat,"A theory for multiresolution signal decomposition the wavelet representation",IEEE Trans. Pattern Anal. Mach.Intell. 11, 674–693 (1989).

[2]. Prabhishek Singh, R S Chadha, "A Survey of Digital Watermarking Techniques, Applications and Attacks", International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 9, March 2013.

[3]. Kanphade, "Reversible Watermarking: A Complete Review", International Journal of Computer Science and Telecommunications [Volume 2, Issue 3, June 2011].

[4]. Daubechies, W. Sweldens," Factoring wavelettransform into lifting steps", J. Fourier Anal. Appl. 4, 247– 269,1998.

[5]. Usha Bhanu, Dr.A.Chilambuchelvan,"A Detailed Survey on VLSI Architectures for Lifting based DWT forefficient hardware implementation",International Journal of VLSI design & Communication Systems (VLSICS) Vol.3, No.2, April 2012.

[6]. Durga Sowjanya, K N H Srinivas, P Venkata Ganapathi, "FPGA IMPLEMENTATION OF EFFICIENT VLSIARCHITECTURE FOR FIXED POINT 1-D DWT USINGLIFTING SCHEME",International Journal of VLSI design &Communication Systems (VLSICS) Vol.3, No.4, August 2012.

[7]. K.Indira Devi, Dr.R.Shanmugalakshmi "A Study on VLSI Architectures of LiftingBased Discrete Wavelet Transform",International Conference on Advanced Computing and Communication Systems (ICACCS -2013), Dec. 19 – 21, 2013.

[8]. S. Cheng, C. Tseng, and M. Cole, "Efficient and effective VLSI architecture for a wavelet-based broadband sonar signal detection system," in Proc. IEEE 14th ICECS, Marrakech, Morocco, Dec. 2007,pp. 593–596.

[9]. N. G. Kingsbury, "Complex wavelets for shift invariantanalysis and filtering of signals", Applied ComputationalHarmonic Anal, vol. 10, no. 3, pp. 234-253, May 2001.