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Types of Three Filter Banks in FPGA

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Abstract: ***In this paper three filter bank structure are evaluated by Field Programming Gate Array implementations. The traditional non polyphase structures, traditional polyphase structure and lifting structures are three filter banks. The compression performance are examined by three filter structure. For the filter coefficients, optimal quantized values are found for each structure. Discrete Wavelet Transform codec generates the best possible Peak signal to noise ratio performance for a given structure using these coefficients, in Discrete Wavelet Transform we use filter bank instead of using a single filter. By evaluating the performance optimal choices can be made for a biorthogonal 9/7 Discrete Wavelet Transform implementation based on the given application. After quantization here filter bank properties are preserved and not the properties of single filter. In this traditional Discrete Wavelet Transform can be implemented in multiple ways and then it introduces figure of merit examined hardware implementation. Two quantization techniques are used to better the performance of quantized filter bank to get higher throughput filter bank in polyphase form is used than non polyphase structure. In lifting structure, six different optimal quantized lifting implementations are designed and evaluated. To accept the proposed scheme, for the 2-dimentional Discrete Wavelet Transform computation this circuit is designed, simulated, and implemented in Field Programming Gate Array.***

Keywords: Field programming Gate Array (FPGA); Discrete Wavelet Transform(DWT);VHDL

1. Introduction

This paper concentrates on a Field Programmable Gate Array (FPGA) implementation of a DWT code for the Biorthogonal 9/7 wavelet. Perfect Reconstruction (PR) filter bank is usually used for the computation of Discrete wavelet transform. The behavior of an FPGA implementation of the filter bank vary depending on Filter bank structure and filter coefficient quantization and the hardware architecture used to implement the filter bank structure.

The image compression ability of the filter bank implementation critically depends on the two perfect reconstruction (PR) conditions: the no-distortion condition and the no-aliasing condition. If irrational coefficient of biorthogonal 9/7 wavelet transform filter used in a floating point format then above stated two perfect reconstruction conditions are satisfied and perfect reconstruction is achieved under lossless compression by filter bank. If we present filter coefficient on a Sum- and – difference of powers of two(SPT) in a multiplier manner, fast hardware implementation on a FPGA can be achieved. Now multiplication is achieved by shifting and adding. So filter coefficient are approximated by fixed point SPT representation that is the coefficient of filter should be quantized. Hardware cost associated with implementing the coefficient is denoted by T which is number of non zero term in the SPT representation of a coincident.

FPGA implementations of three filter bank structures is checked in this paper The three structures are traditional lifting structure, polyphase structure and traditional non-polyphase structure. The above stated three structures are examined in terms of compression performance using peak signal to noise ratio (PSNR) and various hardware metrics. The Quantized Optimal value for each structure are found for filter coefficient. These coefficients are needed for the fast implementation, multiplier less Discrete Wavelet Transform (DWT) codec that produces the best PSNR behavior of the structure. This comprehensive behavior analysis makes it possible to make best choices for a biorthogonal 9/7 DWT implementation based on the requirement of the given application.

Hardware metric such as throughput and latency are found out by using filter bank structure and filter coefficient has its effect on the signal processing properties of the filter bank and determines its image compression view. Latency is power consumption properties are found using hardware architecture of filter bank.

2. Design and Implementation

2.1 Filter Structure and Quantization

Before implementation we need to quantize filter coefficient in fast hardware. Because of this frequency response of the filter is changed. If quantized filter is used in filter bank it affects perfect reconstruction properties of filter bank and also image compression performance is compromised. If we quantize filter coefficient in such a manner so that filter bank properties are conserved than minimum degradation will be caused to image compression properties. The coefficient quantization filter structure plays an important role in the performance of filter bank. Some filter structure are not affected by coefficient quantization than others and these filter structure can be utilized to minimize performance degradation of the filter bank. This paper examines two filter structure and two compensating coefficient quantization method to obtain better performance from multiplier quantized filter banks. Instead of using optimization technique the new method make use of perfect reconstruction requirement of filter bank. The design process can be widely used with any biorthogonal perfect reconstruction filter bank having finite length filters. If each filter remains symmetric after coefficient quantization then linear phase and no-aliasing condition can be saved. The magnitude response of the low pass branches of the filter bank find out that no distortion condition is satisfied or not.

2.2 Polyphase Implementation

In this section of data throughput, regardless of whether the filters are implemented in the direct form or as a cascade of sections. During analysis stage down sampling and filtering is performed. In this method half samples are discarded which are computed by filters and due to this output rate in analysis stage is half of input rate. During synthesis stage the up sampling operation is done before filtering operation at double input rate. Since up sampling inserts zeros in the input data half of the multiplier in the synthesis filter are multiplied by zero so half mathematical operation is wasted.

2.3 Direct form Implementation

Sixteen coefficients must be quantized for direct form implementation of two low pass filter. The number of non zero terms in the SPT representation of coefficient should be kept to minimum value so that test hardware performance is achieved. The important part here is that how to distribute available T across the coefficient so that best compression performance is achieved. In the first method uniform distribution of the T across sixteen coefficient are done. This allocation is referred as uniform allocation. Here improve performance of the filter bank is achieved by taking advantage of the relationship between the quantized filter and the no distortion perfect reconstruction condition.

2.4 Direct Polyphase Structure

In a polyphase, direct implementation of biorthogonal 9/7 filter bank filter is divided into even and odd phase. Still each phase remains symmetric. A direct form polyphase implementation needs the sum total no. of SPT terms on the direct form without polyphase. But direct form polyphase implementation is advantageous because we get double throughput without substantial change in hardware cost. Both structures gives same data output and their effect on image compression quality is same. Both structures when implied encounter some problem.

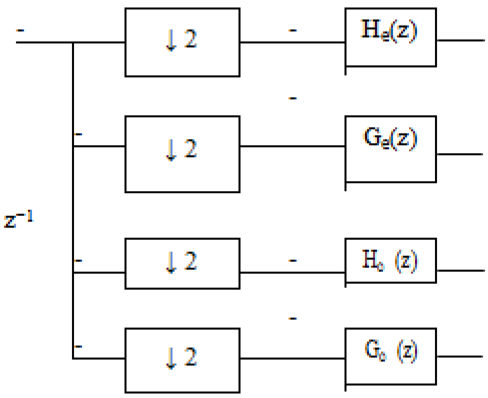
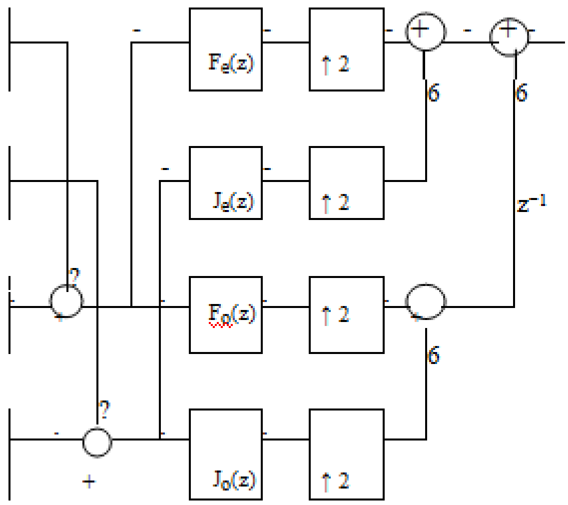


Figure 1: Direct Polyphase Structure for the Filter Banks

2.5 Cascade Structure

In polyphase cascade structure the filter is designed such that down sampling operation is moved to filter input using noble identity. The equation in polyphase representation of both cascaded structure are used such that delays are first grouped and factored out and then noble identity is employed. In cascade filter structure zeros at z=-1 are placed in a separate filter section to ensure that they are not disturbed even after coefficient quantization in the below figure shows.



2.6 Sections headings

Section headings come in several varieties:
1. first level headings: 1. Heading 1
2. second level: 1.2. Heading 2
3. third level: 1.2.3 Heading 3
4. forth level: (a) Heading 4
5. fifth level: (1) Heading 5

2.7 References

Number citations consecutively in square brackets [1]. The sentence punctuation follows the brackets [2]. Multiple references [2], [3] are each numbered with separate brackets [1]–[3]. Please note that the references at the end of this document are in the preferred referencing style. Please ensure that the provided references are complete with all the details and also cited inside the manuscript (example: page numbers, year of publication, publisher’s name etc.).

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If you are using *Word*, use either the Microsoft Equation Editor or the *MathType* add-on (http://www.mathtype.com) for equations in your paper (Insert | Object | Create New | Microsoft Equation *or* MathType Equation). “Float over text” should not be selected.

Number equations consecutively with equation numbers in parentheses flush with the right margin, as in (1). First use the equation editor to create the equation. Then select the “Equation” markup style. Press the tab key and write the equation number in parentheses.

$$E = \sum_{p=1}^{P} \sum_{k=1}^{K} (\delta_{pk}^{o})^2 \quad (1)$$

3. Other recommendations

Equalize the length of your columns on the last page. If you are using *Word*, proceed as follows: Insert/Break/Continuous.

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