AI Based Low complexity VLSI Architectures for 2D Daubechies Wavelet Filters for DSP Applications

A.Lakshminarayanan¹, N.Jayapal², K.Shajudeen³, K.Kumar⁴, V.Krishnakumar⁵

Assistant Professor, Dept of ECE, Kongunadu College of Engineering and Technology, Thottiyam, Tamilnadu, India ¹
Assistant Professor, Dept of ECE, Kongunadu College of Engineering and Technology, Thottiyam, Tamilnadu, India ²
Assistant Professor, Dept of ECE, Kongunadu College of Engineering and Technology, Thottiyam, Tamilnadu, India ³
Assistant Professor, Dept of ECE, Kongunadu College of Engineering and Technology, Thottiyam, Tamilnadu, India ⁴
Assistant Professor, Dept of ECE, Kongunadu College of Engineering and Technology, Thottiyam, Tamilnadu, India ⁵

ABSTRACT: The field of separate rippling transforms has been attracting substantial interest partially as a result of the rippling analysis being capable of modeling an indication into a specific set of basic functions equipped with sensible spectral properties. Rippling analysis has been accustomed observe system non-linearities by creating use of its localization feature. DWT-based multi-resolution analysis results in each time and frequency localization. Separate rippling transforms square measure square measure of interest in signal and image process as a result of their capability of signal decomposition, denoising, and event detection. This paper proposes an algebraically number primarily based multi-encoding of Daubechies-4 and -6 2-D rippling filters having error-free integer-based computation. Digital VLSI architectures using parallel channels square measure projected, physically completed and tested. The multi-encoded AI framework permits a multiplication-free and computationally correct design. It additionally guarantees a noise-free computation outturn the multi-level multi-rate 2-D filtering operation. one final reconstruction step (FRS) furnishes filtered and down-sampled image outputs in fixed-point, leading to low levels of division noise.

KEYWORDS: Final reconstruction step, DWT, AI

I. INTRODUCTION

The DWT has extensively been utilized in a large variety of applications with numerical analysis, image and video cryptography, pattern recognition, medical and telemetric imaging, etc. The DWT decomposition by mallat shows that DWT may be viewed as a multiresolution decomposition of signal. DWT implies it decomposes the signal into its parts in several frequency bands. The Inverse DWT will reconstruct the signal from its octave band parts. Once its inclusion in JPEG 2000 compression normal, important analysis has been done to optimize the DWT implementation to cut back the procedure complexity. Among a large vary of wavelets, the Daubechies wavelets embody members starting from extremely localized to extremely sleek and might give glorious performance in compression [1]. Among the members of the family, the primary two applications. Whereas pressure medical pictures, the key here is to preserve the maximum amount crucial info as potential within the reconstructed image in order that correct identification is feasible. There are many economical implementations of ripple filters projected for applications in image process and Daubechies 6-tap area unit fashionable selections in medical imaging. The employment of standard fixed-point binary illustration for implementing separate ripple coefficients introduces round-off or approximation errors at the terribly starting of the method [8]. The error is as a result of the dearth of tangible illustration of the irrational numbers that kind the constant basis.

These errors tend to expand because the calculations progress through the design, degrading the standard of image reconstruction. A lossless mapping technique, referred to as pure mathematics whole number quantisation, may be wont to minimize the approximation error and expeditiously calculate the DAUB4 and DAUB6 coefficients.

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The AI theme is split into two halves, the first stage is predicated on factorisation and decomposition of remodel matrices exploiting the radially symmetrical structure. Once the decomposition, we tend to map the irrational remodel basis coefficients mistreatment four-dimensional pure mathematics integers that lead to precise illustration and less complicated implementation [7].

II. RELATED WORK

In the AI illustration, irrational numbers concerned within the DWT method are encoded into integers associated to a given AI basis. The computing design is replaced with a parallel channel model [2]. Once computation, ensuing encoded numbers are mapped into fixed-point illustration within the final reconstruction step (FRS). The FRS is that the solely doable supply of machine error during a given AI-based framework.

AI cryptography will address the machine noise injection in ripple analysis systems [6]. A major advantage of the AI cryptography is its capability of mapping the required irrational ripple coefficients into vectors or arrays of integers. Therefore, wavelet decomposition is often performed while not errors during a vectorial framework consisting completely of number operations. Thus, the irrational coefficients of the Daubechies filters are often diagrammatic into integers, in step with a specific AI basis.

III. DAUBECHIES WAVELETS

This section provides a introduction to Daubechies wavelets. These wavelets include members starting from extremely localized to extremely sleek Daubechies-2 to Daubechies-20 and conjointly provide glorious performance in compression. The Daubechies moving ridge coefficients square measure supported computing moving ridge coefficients.

1. The conservation of space underneath a finite length
2. The accuracy conditions
3. The proper reconstruction conditions

The Daub-4 wavelets square measure typically used in applications wherever the signals square measure sleek and slowly variable, the Daub-6 wavelets square measure used for signals bearing abrupt changes, spikes, and having high unwanted noise levels. Daubechies-4 and -6 faucet filter coefficients square measure irrational varieties and can’t be delineated specifically in commonplace finite precision number systems like the two’s complement fixed-point format, the fixed-point representations incur errors once used in arithmetic processors. These errors, as a result of quantisation, overflow, and underflow, propagate through the complete method of moving ridge decomposition. The results of the moving ridge analysis possess a reduced ratio. Typical 2-D Daubechies-4 and -6 filter banks use 1-D filters as their building block. The 1-D Daubechies-4 filters measure repeatedly applied to row and column wise operations to yield 2-D filtering.

Figure 1. FP-based DAUB6 filter architecture
A. The Problem of Fixed-Point Errors

Filter banks associated to Daubechies wavelets have irrational coefficients whose illustration in fixed-point needs truncation or estimation [2, 6, and 16]. Such approximations introduce illustration errors that propagate through a given filter bank. Moreover, the longer the desired filter bank provides larger process error could become. This method affects a lower obtained ratio of the ensuing knowledge.

B. AI Based 4-Tap and 6-Tap 2-D Daubechies Wavelet Filter Banks

In propose a replacement multi-encoding technique that achieves precise computation of multi-level 2-D Daubechies rippling transforms mistreatment algebraically number secret writing. Compared to existing AI styles in literature [1, 3, 6], the planned style will cipher rippling image approximations entirely over number fields and with one FRS in a very strictly AI based mostly 2-D design. The planning avoids the requirement of intermediate reconstruction steps.

Moreover, the planned design is sought-after to be multiplier-free. Such style facilitates accuracy, speed, and comparatively smaller space on chip further as value of style. The new style is multi-encoded and multi-rate, in operation over AI with no intermediate reconstruction steps. During this framework, error-free computations are performed till the ultimate FRS. Our design emphasizes on quality of output image and speed by commerce complexity and power consumption for accuracy.

Figure 2. Diagram of a single application of the 2-D wavelet filter bank.

Figure 3. Recursive application of the 2-D wavelet filter bank

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consisting solely of number operations. Thus, the irrational coefficients of the Daubechies filters are described into integers, consistent with a particular AI basis [3, 6].

![Daub-6 AI Filter Structure](image)

**Figure 4. Daub-6 AI Filter Structure**

**IV. EXPANSION FACTOR METHOD**

Expansion factors are scaling constants sometimes used within the style of approximate transforms. Survey the subject during this context. Recently this system was extended and custom-made to the look of ultimate reconstruction blocks associated with AI based mostly architectures. The enlargement issue methodology is anticipated to supply higher results for larger basis. Indeed, the Daub-4 design couldn't like the enlargement methodology since its basis contains just one non-unity element: $\zeta$.

However, as a result of the AI basis associated with the Daub-6 theme has 3 non-unity components $\zeta_1, \zeta_2, \zeta_1\zeta_2$, the enlargement issue methodology could lead on to helpful architectures within the FRS following procedure search algorithms for appropriate number mixtures. Within the next section we offer activity results regarding the enlargement issue methodology.

**V. FPGA IMPLEMENTATION AND RESULTS**

The architectures for Daub-4 and -6 filter banks were implemented on Xilinx Virtex xc6vcx240t-1ff1156 device using the ML605 evaluation board. The designs were tested with six different standard images obtained from. Gray 512x512 images Woman, Cameraman, and Reflection to the Daub-4 filter banks whereas Mandrill, Lena, and CT head were submitted to the Daub-6 filter banks. Hardware results were verified with Matlab, hardware results from the Xilinx FPGA for the Daub-4 and -6 filter banks. Table 1 shows a performance comparison among proposed Daub-4 and -6 architectures for single level decomposition of 8-bit Lena image. For comparison, we devised a version of the proposed system that operates over fixed-point arithmetic instead of AI-based arithmetic. For such, we employed 8 bits for word size with 6 fractional bits. In this case, the required filter banks were implemented by quantizing the exact filter coefficients into the fixed-point representation. Notice that the fixed-point scheme incurs coupled quantization noise, whereas the AI-based architecture is immune to this source of contamination.

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The AT product may be a customary performance metric in digital hardware designs. It refers to chip-area and speed of the look. Lower AT values indicate a better speed of operation. In an FPGA, the realm is provided by the amount of slice LUTs used for logic given by the FPGA style tool referred to as XFLOW and therefore the time is just the crucial path delay. Amount AT2 is helpful, once clock speed is the driving issue of style improvement, for high-throughput realizations.

Figure 5 Multi-level AI filter bank with final reconstruction step (FRS)

Figure 6 AI Result

Figure 7 AI Data selection path
In figure 6,7,8 represents the AI encoding scheme with desired input output.

Table 1. Comparison table 4 Tap and 6 Tap Filter

<table>
<thead>
<tr>
<th>ALGORITHM</th>
<th>AREA IN TERMS OF GATE COUNT</th>
<th>POWER IN mW</th>
<th>DELAY IN ns</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI without encoding algorithm 4 Tap</td>
<td>12,944</td>
<td>8784</td>
<td>21.9</td>
</tr>
<tr>
<td>AI without encoding algorithm 6 Tap</td>
<td>3000</td>
<td>10101</td>
<td>4.43</td>
</tr>
<tr>
<td>AI with encoding algorithm 6 Tap</td>
<td>14,735</td>
<td>18,720</td>
<td>38.45</td>
</tr>
<tr>
<td>AI with encoding algorithm 4 Tap</td>
<td>4276</td>
<td>13279</td>
<td>11.27</td>
</tr>
</tbody>
</table>

Xilinx power analyzer was used to research the facility consumption on Xilinx FPGA Virtex-6 device. The quiescent power dissipation may be a combined result of standby and discharge power dissipations. At forty nm method technology static power dominates dynamic power. Dynamic power represents the unsteady power because the style runs and is that the add of short-circuit and electrical phenomenon power dissipations. The figures 6, 7, 8,9,10 represent the performance analysis of 4 Tap and 6 Tap filter. The proposed AI based multi encoded algorithm having reduced amount of gate count and power consumption.
VII. CONCLUSIONS

We planned associate degree optimized multi-rate 1-D/2-D Daub-4 and Daub-6 filter bank architectures that area unit strictly AI-based, and multi-encoded. In addition, the introduced styles area unit capable of furnishing willy-nilly high numerical accuracy mistreatment error-free whole number arithmetic. In fact, the planned architectures preserve all options of our earlier architectures like (i) Error-free computation with reduced delay, (ii) outlined over integers with reduced power, and (iii) freed from multiplications with scale back part quality. It additionally reduces hardware quality (number of adders) resulting in sizeable reduction in price for the hardware realization of multi-level 2-D DWTs of Daubechies 4-tap and 6-tap filter banks. The FRS is that the only supply of process error. By using AI coding, ensuing ripple rotten pictures had SNR and PSNR figures improved by close to 30–35% compared to a counter- half fixed-point system with 8-bit word length and six fragmental bits.

REFERENCES