Image Compression using Lifting Based Wavetet Transform

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Abstract--**In this paper lifting based wavelet transform is proposed for image coding. The main contribution of the proposed approach consists of cdf97 and legall53 wavelet filters. Experimental results show that proposed lifting wavelet transform with these filters. The 5/3 tap and 9/7 tap wavelet filters is tested for image compression and performance is analyzed with PSNR and visual quality. Lifting provides insight into the construction of the wavelet transform.**

Keywords: Wavelet transform, lifting, Image compression, transform coding.

I. INTRODUCTION

Due to its many advantages such as multiresolution representation, good energy compaction and decorrelation the discrete wavelet transform (DWT) has become one of the most important techniques for image and video compression in the last decade and been adopted by JPEG2000 standard [1].The wavelet-based JPEG2000 not only presents superior coding performance over the DCT-based JPEG .

Conventionally, 2-D DWT is carried out as a separable transform by cascading two 1-D transforms in the horizontal and vertical direction [3]. Therefore, vanishing moments of the high-pass wavelet filters exist only in these two directions. The wavelet transform can be efficiently implemented by the lifting scheme [4], where the FIR wavelet filter can be factored into several lifting steps, referred as split, predict, update, and normalize, respectively.

CDF 9/7 and LEGALL 5/3 tap with and lifting implementation is proposed. We are using SPIHT coder [5] and performance is analysed.

II. LIFTING SCHEME OF CDF 97 WAVELET FILTER

Lifting scheme is derived from a polyphase matrix representation of the wavelet filters, a representation that is distinguishing between even and odd samples. Using the algorithm of filter factoring, we split the original filter into a series of shorter filters (typically Laurent polynomials of first degree). Those filters are designed as lifting steps; each step one group of coefficients are lifted (altered) with the help of the other one (classical dyadic transform always leads to two groups of coefficients, low-pass and high-pass).
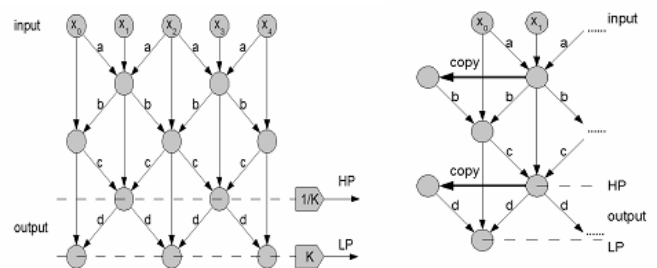

Figure 1: CDF9/7 lifting scheme. Source signal is defined as x, the result is taken from HP and LP branches for high-pass and low-pass coefficients, respectively; a,b,c,d and K are constants computed by filter factorization process. Picture on the right is demonstrating boundary handling.

The code is written specialized for the CDF 9/7 wavelet in lifting scheme implementation. Sweden's lifting scheme [4] represents a wavelet transform as a sequence of predict and update steps. Let X=[X (1), X (2), ... X(2N)] be an array of length 2N. The lifting scheme begins with the "poly phase decomposition" splitting X into two sub bands, each of length N:

Xo=[X(1),X(3),X(5),... X(2N-1)],

Xe=[X(2),X(4),X(6), ... X(2N)].

Since Xo and Xe can be merged to recover X, no information has been lost. Next, the scheme performs lifting steps on the subbands Xo and Xe. Let p be a filter, then Xe'= Xe + p*Xo is called a "prediction" step, where * denotes convolution. Similarly, Xo'= Xo + u*Xe is called an "update" step. Notice that Xe can always be recovered from Xe' with Xe'= Xe - p*Xo.

This simple relationship between a forward step and an inverse step is the key to the lifting scheme: any sequence of prediction and update steps can be "undone" to recover X_o and X_e.

Any FIR wavelet transform can be factored into a sequence of lifting steps[4]. For the CDF 9/7 wavelet, the lifting scheme decomposition used in wavelet cdf97 is

$X_o = [X(1),X(3),X(5),... X(2N-1)]$

$X_e = [X(2),X(4),X(6), ... X(2N)]$

$X_e^1(n) = X_e(n) + \alpha(X_o(n+1) + X_o(n))$

$X_o^1(n) = X_o(n) + \beta(X_e^1(n) + X_e^1(n-1))$

$X_e^2(n) = X_e^1(n) + \delta(X_o^1(n+1) + X_o^1(n))$

$X_o^2(n) = X_o^2(n) + \gamma(X_e^2(n) + X_e^2(n-1))$

The sub bands are then normalized with $X_o^3 = \kappa X_o^2$ and $X_e^3 = \kappa^{-1} X_e^2$. For a multi-level decomposition, the algorithm above is repeated with $X = X_o^3$. The numbers α, β, δ, γ, κ are irrational values approximately equal to $\alpha \approx -1.58613432$, $\beta \approx -0.05298011854$, $\delta \approx 0.8829110762$, $\gamma \approx 0.4435068522$, $\kappa \approx 1.149604398$

The inverse CDF 9/7 transform is done by performing the lifting steps in the reverse order and with α, β, δ, γ negated.

III. SPIHT CODING SCHEME

When the decomposition image is obtained, we try to find a way how to code the wavelet coefficients into an efficient result, taking redundancy and storage space into consideration. SPIHT [5] is one of the most advanced schemes. The basic principle is the same; a progressive coding is applied, processing the image respectively to a lowering threshold. The difference is in the concept of zero trees (spatial orientation trees in SPIHT). This is an idea that takes bounds between coefficients across sub bands in different levels into consideration. The first idea is always the same: if there is an coefficient in the highest level of transform in a particular sub band considered insignificant against a particular threshold, it is very probable that its descendants in lower levels will be insignificant too, so we can code quite a large group of coefficients with one symbol .SPIHT makes use of three lists – the List of Significant Pixels (LSP), List of Insignificant Pixels (LIP) and List of Insignificant Sets (LIS). These are coefficient location lists that contain their ordinates. After the initialization, the algorithm takes two stages for each level of threshold – the sorting pass (in which lists are organized) and the refinement pass (which does the actual progressive coding transmission). The result is in the form of a bit stream.
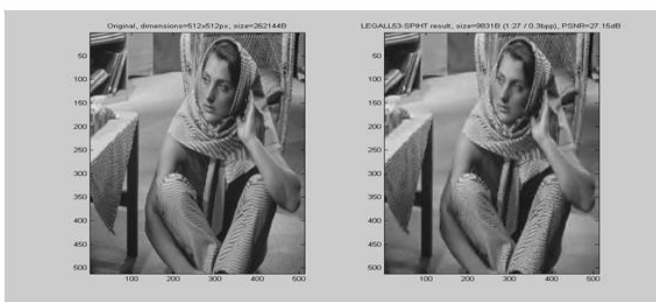

Figure 2: Barbara image compression result at 0.3 bpp using Legall5/3 wavelet filterbank

Figure 3: Barbara image compression result at 0.3 bpp using CDF97 wavelet Filterbank

Figure 4: Man image compression result at 0.3 bpp using Legall5/3 wavelet filterbank

IV. SIMULATION RESULTS

This paper proposed an implementation of SPIHT coder and decoder using CDF97 and LEGALL53 wavelet filters with lifting scheme. After conducting simulation on group of images PSNR is computed in dB. All tests are performed using well known test images with resolution 512x512. The measurements were performed for a decomposition depth 5. The result shows that CDF 97 filter bank produces best result in image compression. All results of simulation are shown in above figures with o.3bpp and proposed wavelet filters.

V. CONCLUSIONS

We have demonstrated image compression based on lifting wavelet transformation technique. The cdf97 and legall53 wavelet filters are used for performance analysis. The fact that CDF9/7 is able to perform best result for PSNR improvement and image quality

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