High-level Implementation of Gray Scale Image Compression Using Lifting Scheme

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Abstract- *Image compression has become one of the most important disciplines in digital electronics because of the ever growing popularity and usage of the internet and multimedia systems combined with the high requirements of the bandwidth and storage space. The increasing volume of data generated by some medical imaging modalities which justifies the use of different compression techniques to decrease the storage space and efficiency of transfer the images over the network for access to electronic patient records. Here we are presented an effective algorithm to compress and to reconstruct gray scale image and communications in medical image. Various image compression algorithms exist in today's commercial market. In this, we are introducing lifting scheme based Haar wavelet transform. The Haar wavelet is famous for its simplicity and speed of computation. Computation of the scaling coefficients requires adding two samples values and dividing by two. Calculation of the wavelet coefficients requires subtracting two samples values and dividing by two.*

Keywords: Lifting Scheme, image compression, bandwidth, wavelet transform, and sampling.

1. INTRODUCTION

The Wim Sweldens 76 developed the lifting scheme for the construction of biorthogonal wavelets. The main feature of the lifting scheme is that all constructions are derived in the spatial domain. It does not require complex mathematical calculations that are required in traditional methods. Lifting scheme is simplest and efficient algorithm to calculate wavelet transforms [1-2]. It does not depend on Fourier transforms. Lifting scheme is used to generate second generation wavelets, which are not necessarily translation and dilation of one particular function. It was started as a method to improve a given discrete wavelet transforms to obtain specific properties. Later it became an efficient algorithm to calculate any wavelet transform as a sequence of simple lifting steps. Digital signals are usually a sequence of integer numbers, while wavelet transforms result in floating point numbers. For an efficient reversible implementation, it is of great importance to have a transform algorithm that converts integers to integers. Fortunately, a lifting step can be modified to operate on integers, while preserving the reversibility. Thus, the lifting scheme became a method to implement reversible integer wavelet transforms. Constructing wavelets using lifting scheme consists of three steps: The first step is split phase that split data into odd and even sets. The second step is predicting step, in which odd set is predicted from even set. Predict phase ensures polynomial cancellation in high pass. The third step is update phase that will update even set using wavelet coefficient to calculate scaling function. Update stage ensures preservation of moments in low pass [3].

2. REASONS FOR THE CHOICE OF LIFTING SCHEME

We have used lifting scheme of wavelet transform for the digital speech compression because lifting scheme is having following advantages over conventional wavelet transform technique. It allows a faster implementation of the wavelet transform. It requires half number of computations as compare to traditional convolution based discrete wavelet transform. This is very attractive for real time low power applications. The lifting scheme allows a fully in-place calculation of the wavelet transform. In other words, no auxiliary memory is needed and the original signal can be replaced with its wavelet transform. Lifting scheme allows us to implement reversible integer wavelet transforms. In conventional scheme it involves floating point operations, which introduces rounding errors due to floating point arithmetic. While in case of lifting scheme perfect reconstruction is possible for loss-less compression. It is easier to store and process integer numbers compared to floating point numbers. Easier to understand and implement. It can be used for irregular sampling

3. LIFTING SCHEME BASED HAAR WAVELET TRANSFORM

Alfred Haar introduced the first wavelet systems in the year 1910. Wavelet systems of the Haar have been generalized to higher order dimension and rank. Two types of coefficients are obtained from the wavelet transform. Scaling coefficients are obtained by averaging two adjacent samples. These scaling coefficients represent a coarse approximation of the speech. Wavelet coefficients are obtained from the subtraction of two adjacent samples. Wavelet coefficients contain the fine details of the speech signal. The Haar wavelet is famous for its simplicity and speed of computation. Computation of the scaling coefficients requires adding two samples values and dividing by two. Calculation of the wavelet coefficients requires subtracting two samples values and dividing by two. The inverse transform simply requires subtraction and addition. Using logical shifts to perform division eliminates the need for a complex divide unit. Furthermore, implementing a logical shift in hardware requires much less power and space than an arithmetic logic unit (ALU). Given the computational requirements, the Haar wavelet is a simple and easy to implement transform.

Computational simplicity makes the Haar transform a perfect choice for an initial design implementation. Let us consider a simple example of Haar wavelet: Let us consider that we have a discrete sequence f(x) which is obtained by sampling continuous signal such as speech signal. Consider two neighboring samples X and Y of this sequence. These two samples show strong correlation. Haar transform will replace value of X and Y by Average and difference:

$$a = (X + Y)/2 \quad (1)$$

$$d = Y - X \quad (2)$$

Simple inverse Haar transform can be used calculate original value of sample X and Y:

$$X = (a - d)/2 \quad (3)$$

$$Y = (a + d)/2 \quad (4)$$

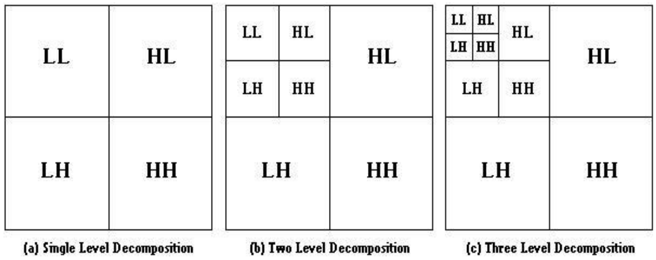

Table 1: Pyramidal Decomposition of an Image

Table 1 shows the process involved in wavelet filter sub band decomposition. The sub bands are labeled as LL, HL, LH and HH respectively [3-4].

LL: Represents approximation content of the image resulting from low pass filtering in both horizontal and vertical directions.

HL: Represents vertical details resulting from vertical low pass filtering and horizontal high pass filtering.

LH: Horizontal details resulting from vertical high pass filtering and horizontal low pass filtering.

HH: Represents diagonal image details resulting from high pass filtering both vertically and horizontally.

4. INTEGER WAVELET TRANSFORM

In wavelet Digital speech signal is a sequence of integer samples; hence speech compression algorithms should work with integers. Apart from speech compression, there are many applications like image compression, image processing etc. require integer wavelet transform because of nature of input data is integer samples. In addition to this the storage and encoding of integer numbers is easier compared to floating point numbers. Filter bank algorithm of wavelet transform work with floating point numbers even though input values actually are integer, carrying out filtering operations on these numbers will transform them in rational or real numbers because the filter coefficients need not be integers. To obtain an efficient implementation of the discrete wavelet transform, it is of great practical importance that the wavelet transform is represented by a set of integers. Because if we store wavelet coefficients as a floating point values it requires 32 bits per coefficients. This is not reasonable in some applications like speech compression. Hence wavelet coefficients are rounded to convert it into integer number for efficient encoding and storage. Because of this rounding process, the original signal cannot be reconstructed from its transform without an error. This is the reason for not getting loss-less speech compression in the filter bank implementation. In wavelet filter decomposition, the sub band image is further split into four groups and the approximation content is again decomposed further into four smaller sub bands.[4] Here detailed contents of the image are highly neglected resulting in poor compression performance due to significant information loss.

5. IMPLEMENTATION

In the IWT implementation, rounding operation introduces non linearity in each step. Proper choice of the best factorization of polyphase matrix of h(z) and g(z) has to be done .The popular criteria are: Figure 1: Pyramidal Decomposition of an Image Method I: Minimally nonlinear iterated graphic function so as to reduce the error norm. It is good for (9, 7) and (5, 7) filter structures. It yields a unique solution. Method II-Closest to one normalization constant method. It can provide multiple solutions. Method III-Minimum number of lifting steps-It is the flexible algorithm to reduce the number of lifting steps which means reduced number of rounding operations. So finally it results is less non linear transforms, and has a direct implication in both software and hardware implementation in terms of speed, memory and chip area [9].

6. SIMULATION RESULTS

Using MATLAB 2010, simulations are performed using a sample image "Hills" in the GUI interface. Taking „Lena" image in Figure 1 the result is shown.

Fig- 1: Simulation result of Image "Hills".

The compression ratio is significantly improved. The transformed and the reconstructed image both are considered. These simulation results summarized in Figure 1. Conform to the fact that implementing the LS improves the compression parameters like PSNR, CR, encoding and decoding. LS invariably represent a distinguished choice for the implementation of lossless compression capability in terms of rate-distortion performance. Figure 1, shows the compression ratio improvement for the image whose simulation results have been performed. The encoding and decoding time is significantly improved to speed up the compression process in this Lifting Scheme. The 5/3 transform corresponds to the fact that high pass filter has five filter taps and low pass filter has three taps in this experiment, which can be modified according to the experiment designer. Best factorization exhibit IWT performance very close to DWT for low bit rates only [10]. As the bit rate grows the nonlinear effects of integer transform are dominant with respect to the quantization error.

Fig- 2: Original image, transformed Image and Reconstructed Image

TABLE-2: Performance parameters of different image

Image	Encoding Time	Decoding Time	Compression Ratio
Rose	2.1977	0.082277	8.91373
Taj Mahal	1.5665	0.062376	8.71131
Camera Man	1.7791	0.080736	7.97836
Rice	1.9339	0.070633	8.90938
Lena	1.9339	0.070633	8.90938
Pearl	1.4391	0.049383	9.94764
Hills	1.6822	0.040064	7.9985

7. CONCLUSIONS

In this paper, superior performance of lossless image compression model using the Lifting Scheme is analyzed and the simulation results agree to such efficient compression model. It has the potential to speed up the splitting and decomposition process by exploiting the features of both low pass and high pass filter taps. In software based video conferencing, Internet browsing, multispectral remote sensing, HDTV and real time image compression systems where speed is a deciding factor, this reversible compression model can work out suitably, without the need of temporary arrays in the calculation steps. The implementation of LS along with IWT definitely improves the PSNR and compression ratio significantly, projecting it to be a more effective and robust compression technique in image processing areas using medical, seismic, satellite, manuscript and heavily edited images. Stemming form these results, VLSI architectures will be projected in future scope for the IWT that are capable of attaining very high frame rates with moderate gate complexity.

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