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The Functional Analysis of Wavelet Transformation along with Lifting Scheme for Image Compression

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Abstract:
In image compression to reduce the redundant data and to reduce the size of the processed image as compared to the original image. As compared to the other conventional lossy compression techniques used, the proposed technique is lossless image compression for both continuous and discrete time cases. The Integer wavelet transformation for speeding up the computation time and reducing the size of the image. We perform the wavelet packet transform (WPT) and then the lifting scheme (LS) are can be constructed by iterating the single wavelet decomposition step on both low pas as well as high pass branches by the bi-orthogonal wavelets. The performance in terms of encoding and decoding time, the peak signal to noise ratio (PSNR), and better compression ratio (CR). The implementation of the lifting scheme the speed up mechanism is possible, thus facilitating a superior image compression lossless model. The project work attempts to highlight the performance analysis of such IWT image compression technique using proposed lifting scheme.

Keywords*: WPT, LS, PSNR, CR, Bi-orthogonal wavelets*

1. Introduction

Image compression means reducing the volume of data for representing an image. The main aim of image compression is to reduce both spatial and spectral redundancy to store or transmit data in a proper manner. After the compression of an image, it is reconstructed at the receiver to reproduce the original image. Various compression techniques are used for this purpose. In lossless image compression, some form of entropy coding is used, while in lossy compression transform coding and predictive coding is used. With the inherent features of the wavelet transform, it provides multi-resolution functionality and better compression performance at very low bit-rate compared with the previous JPEG standard.[1] For this purpose many wavelet based algorithms have been implemented. For constructing bi-orthogonal constructed by the lifting scheme have been identified as very promising filters for lossless/lossy image compression applications. Since the lifting scheme makes optimal use of similarities between the high and low pass filters, the computational complexity can be reduced by a factor of two wavelets transform can be calculated even with only integer addition and shift operation which makes the computation faster. Besides, the transform is reversible which means that it can be used for both lossless and lossy image compared with traditional fast wavelet transform algorithms, with certain modifications, the corresponding wavelet transform can be calculated even with only integer addition and shift operations which makes the computation faster. Besides the transform is reversible which means that it can be used for both lossless and lossy image compression. [7][8][10]

2. Wavelet Transform

Wavelets are functions defined over a finite interval and having an average value of zero. The basic idea of the wavelet transform is to represent any arbitrary function (t) as a superposition of a set of such wavelets or basic functions. These basic functions or baby wavelets are obtained from a single prototype wavelet called the mother wavelet, by dilation and translation operation. Discrete Wavelet Transform of a finite length signal s(n) having N components, for the image is expressed by an N x N matrix. [1][10]

2.1. Wavelet Filter Decomposition and Sub-Band Coding

2.1.1. Wavelet Filter Decomposition

For the designing of filters, sub-band coding is used. Sub-band coding is a coding strategy that tries to isolate different characteristics of a signal in a way that collects the signal energy into few components. This is referred to as energy compaction. Energy compaction is desirable because it is easier to efficiently encode these components than the signal.

The most commonly used implementation of the discrete wavelet transform (DWT) consists of recursive application of the low-pass/high-pass one-dimensional (1-D) filter bank successively along the horizontal and vertical directions of the image. The low-pass filter provides the smooth approximation coefficients while the high-pass filter is used to extract the detail coefficients at a given resolution.

Both low-pass and high-pass filters are called sub-bands. The number of decompositions performed on the original image to obtain sub bands is called sub-band decomposition level.

The high pass sub-band represents residual information of the original image, needed for the perfect reconstruction of the original image from the low-pass sub-band while the low pass sub-band represents a down sampled low- resolution version of the original image. It is used for computer and human vision, musical tone generation, FBI finger print compression.

The filtering step is followed by a sub-sampling operation that decreases the resolution from one transformation level to the other. After applying the 2-D filler bank at a given level n, the detail coefficients are output, while the whole filter bank is applied again upon the approximation image until the desired maximum resolution is achieved. Fig.1 shows the wavelet filter decomposition. The sub-bands are labeled by using the following symbols [3] [8]

- **LL** is the approximation image at resolution (level decomposition) n, resulting from low-pass filtering in the vertical and horizontal directions.
- **HL** represents the vertical details at resolution n, and results from vertical low-pass filtering and horizontal high-pass filtering.
- **LH** represents the horizontal details at resolution n, and results from horizontal low-pass filtering and vertical high-pass filtering.
- **HH** represents the diagonal details at resolution n, and results from high-pass filtering in both directions.

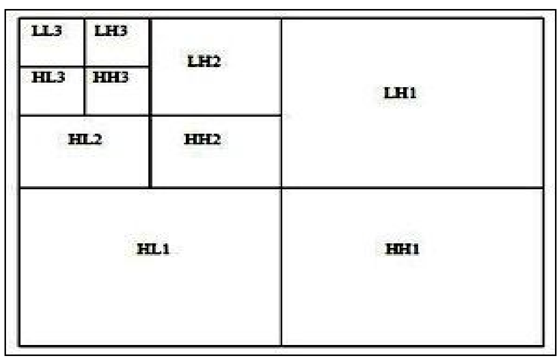

Figure 1: Wavelet Filter Decomposition

3. Integer Wavelet Transform

A more efficient approach to lossless compression is the use of integer transforms, such as Integer Wavelet Transform. The transform coefficients exhibit the feature of being exactly represented by finite precision numbers, and this allows for truly lossless coding.

Recently, the lifting scheme (LS) has been introduced for the efficient computation of DWT. Its main advantage with respect to filter bank structure lies in its better computational efficiency and in fact it enables a new method for filter design. Moreover, the IWT can be computed from any real valued wavelet filter by means of modification of LS. Therefore the LS represent a distinguished choice for the implementation of encoders with progressive lossy to lossless compression capabilities, providing a common core for computing both DWT and IWT. [9]

Integer Wavelet Transform is much faster than the floating point arithmetic in almost all general purpose computers because the floating point wavelet transform demands for longer data length than the integer wavelet transform does. Another benefit of using integer wavelet is the reversibility. That is, the image can be reconstructed loss-lessly because all the coefficients are integers and can be stored without rounding off errors. [9]

3.1. Lifting Scheme

Since the lifting scheme makes optimal use of similarities between the low and high pass filter, the computational complexity can be reduced by a factor of two compared with traditional fast wavelet transform algorithm. With certain modifications, the corresponding wavelet transform can be calculated even with only integer addition and shift operations which makes the computation even faster. It can be used for lossless and lossy image compression because this transform is reversible. [11][6]

The Forward lifting scheme wavelet transform divides the data set being processed into an even half and odd half. Lifting scheme algorithms have the advantage that they do not require temporary arrays in the calculation steps, as is necessary for some versions of the Daubechies D4 Wavelet algorithm. The Predict step calculates the wavelet function in the wavelet transform. This is a high Pass filter. The update step calculates the scaling function, which results in a smoother version of the data. This operation consists of three steps. [3]

1) First, the input signal s[n] is down sampled into the even position signal $s_e(n)$ and the odd position signal $s_o(n)$, then modifying these values using alternating prediction and updating steps.

$s_e(n) = s[2n]$ and

$s_o(n) = s[2n+1]$

2) A prediction step consists of predicting each odd sample as a linear combination of the even samples and subtracting it from the odd sample to form the prediction error.

3) An update step consists of updating the even samples by adding them to a linear combination of the prediction error to form the updated sequence.

The prediction and update step may be calculated in several steps until the forward transform is reached.

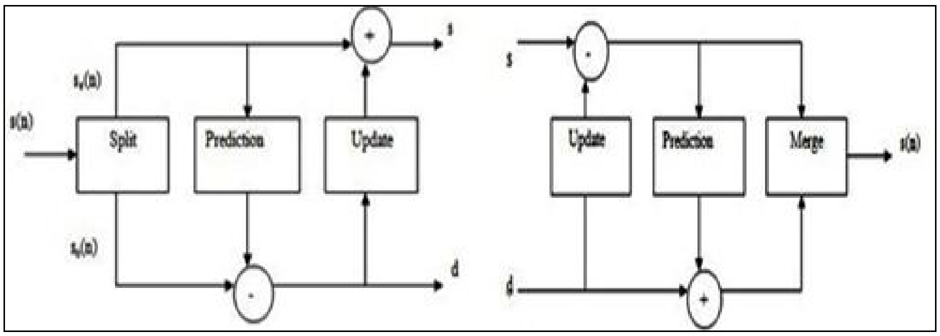

Figure 2: Lifting Scheme of forward wavelet transform
Figure 3: Lifting Scheme of inverse wavelet transform

4. Proposed Method

To get the perfect reconstruction of the forward and inverse IWT of the image, we round off the result of each filter (see Fig.2, Fig.3) right before adding or subtracting operation. The same procedure is applied to the IWPT which leads to the integer wavelet transform. The IWPT tree can be built by iterating the single wavelet decomposition step on both the low-pass and high-pass branches, with rounding off in order to achieve the integer transforms. The performance of discrete wavelet transform based coding also depends on the wavelet decomposition structure. In wavelet decomposition, the approximation component of the image is further decomposed, but in the wavelet packet transform, the approximations as well as detailed components are split. [2][5]

5. Simulation Results

Using MATLAB 7.8 simulations are performed using two different images in the GUI interface. In the first case taking image 'photographer' in Fig.5 the result is shown.

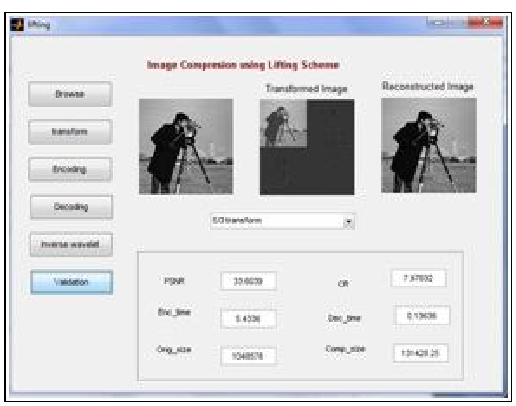

Figure 4: Simulation result of image 'Photographer

The compression ratio is significantly improved. The transformed and the reconstructed image both are considered. One more simulation result using 'grain 'image is shown in Fig. 6.These simulation results conform to the fact that implementing the LS improves the compression parameters like PSNR, CR, encoding and decoding time.

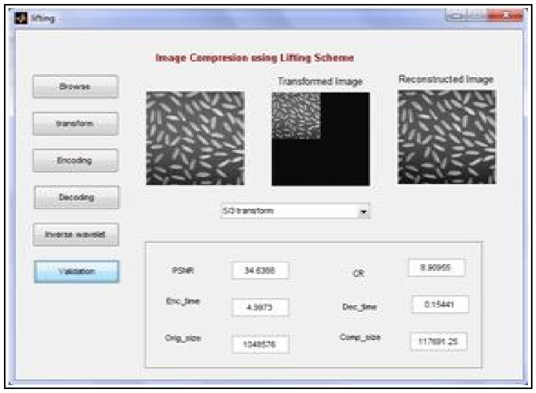

Figure 5: Simulation result of image 'Grain'

Parameter	Image 1 'Photographer'	Image 2 'Grain'
PSNR	33.6039	34.6388
Compression ratio	7.97832	8.90955
Encoding Time	5.4336s	4.9973s
Decoding Time	0.13636s	0.15441s

Table 1: Performance parameters of two Images under test

Table 1 shows the compression ratio improvement for the two images 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.

6. Conclusion

In this project, lossless image compression model using the Lifting Scheme is projected and the simulation results agree to the superior performance of 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 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.

7. References

1. Cebrail Taskin, Serdar Kür at "An Overview of Image Compression Approaches" IEEE, Third International Conference on Digital Telecommunications, 2008.
2. S.Dewine and Comelis, "Lossless integer wavelet transform", IEEE Signal Processing Mar. 1997, Vol 4, pp.158 160.
3. Anoop Mathew and Bensiker Raja Singh D, "Image Compression using Lifting based DWT", International Journal of computers, Information Technology and Engineering, Jan-June 2009.
4. Amir Averbuch, Danny Lazar and Moshe Israeli" Image Compression using wavelet transform and multiresolution decomposition" IEEE Transactions on Image Processing, Vol. 5, no. 1, January 1996.
5. G. K. Kharate, A. A. Ghatol and P.P. Rege, "Image Compression Using Wavelet Packet Tree" ICGST-GVIP Journal, Vol. 4, Issue (7), July 2005.
6. Wade Spires, "Lossless Image Compression via the Lifting Scheme", University of Central Florida, November 2005.
7. Chengjiang Lin, Bo Zhang and Yuan F. Zheng, "Packed Integer Wavelet Transform constructed by Lifting Scheme" International Journal of computers, Information Technology and Engineering, June 2008.
8. Dr. Ban N. Thanoon "Using Wavelet Transform, DPCM and Adaptive Run length encoding to compress images" 6th International Conference on Computer Information Systems and Industrial Management Applications (CISIM'2007)
9. Aree A. Mhammad and Loay E. George, "Intraframe Compression Using Lifting Scheme Wavelet-Based Transformation", (JZS) Journal of Zankoy Sulaimani, December 2008, 11(1) Part A (53-60).

10. Subhasis Saha, “Image Compression from DCT to Wavelets: A Review”, the ACM Student Magazine.
11. Geert Uytterhoeven, Dirk Roose and Adhemar Bultheel, “Integer Wavelet Transforms using the Lifting Scheme”, CSCC’99 Proceedings, Pages: 6251-6253.
12. Daubechies and W. Sweldens, “Factoring Wavelet Transforms into Lifting Steps”, J. Fourier Anal. Appl., 1998, Vol. 4, no.3, pp. 247-269.