Robust Image Compression using Integer Wavelet Transform Exploiting Lifting Scheme

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***Abstract*- In image compression, the motive is to reduce the data redundancy significantly, both in spatial and frequency domain, without much affecting the quality of the picture. Almost lossless reversible image compression model is proposed for both continuous and discrete time cases, exploiting integer wavelet transform(IWT) employing lifting scheme(LS).Unlike its conventional counterpart in wavelet decomposition,here both approximation as well as detailed image contents are splitted providing better compression ratio. Both forward and inverse lifting schemes are exploited so as to reduce the computational complexity and achieve superior compression performance in terms of encoding time, decoding time, PSNR and better compression ratio(CR). Bi-orthogonal wavelets are constructed using lifting scheme that makes optimal use of both high pass and low pass filter values,with addition and shift operations to be performed on the resulting wavelet coefficients. This paper projects the robustness of IWT employing LS used in real time compression of images involving non smooth domains.**

***Keywords* – Lifting scheme LS, IWT,PSNR,CR,DWT, Bi-orthogonal wavelets.**

I. INTRODUCTION

Data redundancy should be minimized by coding, interpixel or psychovisual redundancy for better transmission and storage of date requiring compact memory size.Restoration of the original image size is done at the receiving end so as to keep the image quality intact, and without losing the inherent quality appreciably. Keeping in view, conventional lossless compression technique like entropy coding or JPEG2000 is used whereas in lossless compression method some form of transform or predictive coding is preferred.[1] Recently, wavelet transform has been greatly appreciated due to its multi-resolution functionality and better compression performance even at a very low bit rate.[10]Simulation results using MATLAB 7.8 environment shows the superior compression parameters using forward lifting scheme for image compression and inverse lifting scheme for reconstruction of the image. The proposed transform technique can be applied to both lossy and lossless image compression models, making it a common core for both IWT and DWT computation.[2][3]This is the robust image compression technique employing Lifting Scheme LS.

II.WAVELET TRANSFORM

Wavelets are small basic functions defined over a limited time and characterized by dilation and translation property. Any arbitrary function can be modeled using many such wavelets.Fourier analysis is the best tool for classical wavelet construction. Conventional method of discrete wavelet transform(DWT) refers to sub band coding,for DWT of a finite length signal s(n) having N components, it is expressed by an NXN matrix.[3] Desirable energy is compacted, and using these filter banks both approximation and detailed analysis of any given image can be attained with remarkable resolution.In wavelet filter decomposition, these 1-D filter banks are converted to 2-D filter bank structures by successive sub-sampling operation.

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

1. **LL-**Represents approximation content of the image resulting from low pass filtering in both horizontal and vertical directions.
2. **HL**- Represents vertical details resulting from vertical low pass filtering and horizontal high pass filtering.

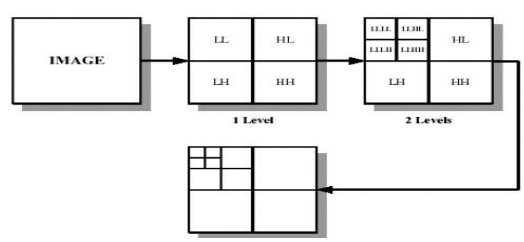

Fig.1.Wavelet filter sub band decomposition

3. **LH-**Horizontal details resulting from vertical high pass filtering and horizontal low pass filtering.
4. **HH**-Represents diagonal image details resulting from high pass filtering both vertically and horizontally.

III.INTEGER WAVELET TRANSFORM

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.

For lossless coding, efficient robust algorithm is proposed in IWT where both approximation and detailed contents of the image are decomposed and yields better compression parameters.[9] A better approach is to round off the values of wavelet transformation rather than using floating point values,which in turn saves storage space.This yields integer values with finite precision.Faster computation of the coefficients is possible by the recursive algorithm, lifting scheme, that is invariably used to compress and restore the original image.[10] This eliminates the need for temporary arrays for storage of the coefficients, and is much faster implementation of wavelet transform.The IWT performance is heavily dependent on the chosen factorization matrix of the wavelet filter, and a proper criteria should be adopted involving factorization selection.[11]The low pass and high pass filters constitute polyphase matrix.Simple shifting and addition operations are performed on the wavelet kernel basis to produce bi-orthogonal second generation wavelets.[8]The following section emphasizes LS both in forward and reverse direction, and the exploitation of this potential algorithm in IWT so as to achieve superior image compression model in multilevel image decomposition.[5]

IV.PROPOSED LIFTING SCHEME

The proposed method of LS is used to separate the odd and even coefficients, thereby producing bi-orthogonal second generation wavelets.In place and much faster computation of DWT is performed is three steps-**split,predict** and **update**.Reverse operation is performed for the signal reconstruction at the receiving side with **update**, **predict** and **merge** steps consequently.[5]Every transform by the lifting scheme can be inverted, making it good for perfect reconstruction. Speed up is increased by a factor of two, utilizing the properties of both high pass and low pass filters.[9]A series of convolution and accumulate operations are performed on the split signal in a recursive manner.Forward LS is used for the image compression and inverse LS is used for the reconstruction of the image.Such transformation is done entirely in the spatial domain, so Fourier analysis no longer plays important role.[8]The signal decomposition is designed by using two filter function h(z) and g(z) respectively as shown in Fig. 2.These wavelet filter function values are entered in the polyphase matrix where they are split and decomposed.Predict and update operators are performed on those coefficients to get the detailed and approximation content of the signal [6]Forward lifting scheme is illustrated in Fig.3.

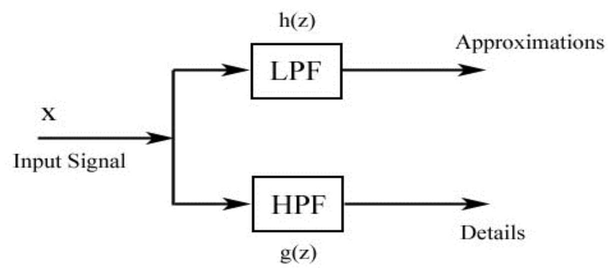

Fig.2.Signal (x) decomposition

The basic steps for forward LS are:

1. SPLIT-Divide into odd & even samples the input co-efficients.
2. PREDICT-Predict the odd sample as linear combination of even values and subtracting it from the odd values to form prediction error.
3. UPDATE-Final step consists of updating the even values by adding them to the prediction error.

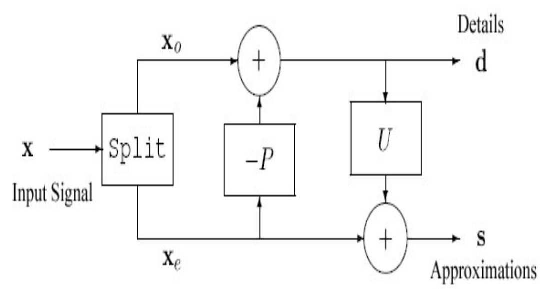

Fig.3.Forward Lifting Scheme

Reverse operation is performed so as to restore the perfect original image by Inverse Lifting scheme.[7]The basic steps are-Update,Predict and Merge so as as shown is Fig.4.The signal s(n) is equal to the input original signal x .[9]

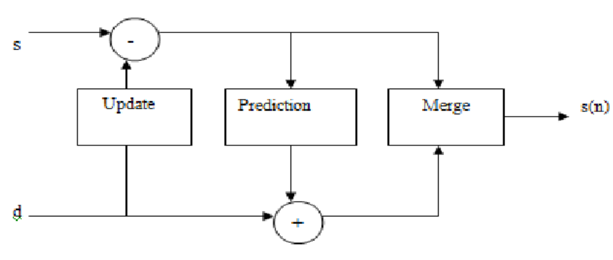

Fig.4.Inverse Lifting Scheme

V.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:

Method I-Minimally non linear iterated graphic function so as to reduce the error norm.It is good for (9,7) and (6,10) 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.[11]

VI.SIMULATION RESULTS

Using MATLAB 7.8,simulations are performed using a sample image "Lena' in the GUI interface. Taking 'Lena' image in Fig.5 the result is shown.

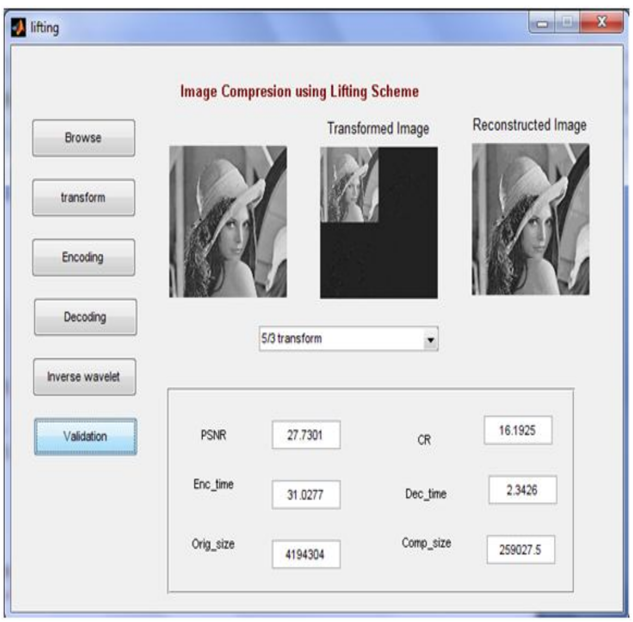

Fig.5.Simulation result of Image 'Lena'.

The compression ratio is significantly improved.The transformed and the reconstructed image both are considered. These simulation results summarised in Table 1. conform to the fact that implementing the LS improves the compression parameters like PSNR,CR,encoding and decoding time.The LS can work with (9,7),(5,3),(2,6),(13,7),(6,10) filters with varying performance.[12]

LS invariably represents a distinguished choice for the implementation of lossless compression capability in terms of rate-distortion performance.

TABLE 1.Performance parameters of Image 'Lena'

Parameter	Image 'Lena'
PSNR	27.7301
Compression ratio	16.1925:1
Encoding Time	31.0277s
Decoding Time	2.3426s

Table 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.[11] As the bit rate grows the nonlinear effects of integer transform are dominant with respect to the quantization error. The effect of finite precision of the lifting coefficients is negligible if small number of bits are devoted for the mantissa, resulting in acceptable performance degradation.

VII.CONCLUSIONS

In this paper, superior performance of lossless image compression model using the Lifting Scheme is analysed 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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