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LOSSLESS IMAGE COMPRESSION VIA LIFTING SCHEME AND SPIHT

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ABSTRACT

Image compression is useful because it helps to reduce the consumption of expensive resources, such as hard disk space or transmission bandwidth .Many compression techniques are in place but there is a scope for high compression with good reconstruction of original image. The problem of reconstruction of data from sub signals from each filter channel is removed by lifting scheme because this structure itself assures reversibility. In this paper we are introducing lifting scheme with SPIHT coder for image compression and the results are obtained for compression ratio, PSNR and RMSE. A study in lossless image compression using the lifting scheme is presented. We first suggest why lossless image compression is an important issue and the general idea behind lifting.

KEYWORDS: Lifting scheme, SPIHT, Compression ratio,PSNR,RMSE.

INTRODUCTION

Image compression is an application of data compression on digital images. Image compression is minimizing the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level. The reduction in file size allows more images to be stored in a given amount of disk or memory space. It also reduces the time required for images to be sent over the Internet or downloaded from Web pages. There are several different ways in which image files can be compressed. For Internet use, the two most common compressed graphic image formats are the JPEG format and SPIHT format.

Wavelet multi-resolution decomposition of images has shown its efficiency in many image processing areas and specifically in compression. Transformed coefficients are obtained by expanding a signal on a wavelet basis. The transformed signal is a different representation of the same underlying data. Such representation is efficient if a relevant part of the original information is found in a relative small number of coefficients. In this sense, wavelets are near optimal bases for a wide class of signals with some smoothness, which is the reason of its interest for compression.

The wavelet-based image encoders improve compression performance relative to the previously existing JPEG standard, as well as having other nice features such as a completely embedded bit-stream representation. Filter banks are the fundamental tool to create discrete wavelet transforms. They are formed by the analysis and synthesis low- and high-pass filters and the intermediate stages composed by down- and up-samplings. Several subsignals are the output of the filter bank analysis part. Each subsignal comes from a different filter channel.

Wavelet are used because the relevant part of the original data is found in relative small no. of coeffients. Wavelet transform decomposes a signal into a set of basis functions. These basis functions are called wavelets. Discrete wavelet transform (DWT), which transforms a discrete time signal to a discrete wavelet representation. Wavelet transform has been popular now due to its time frquency representation. wavelet transform also called as a sub band coding or multi resolution analysis.

Image compression can be lossy and lossless. Lossless compression is sometimes preferred for artificial images such as technical drawings, icons or comics. This is because lossy compression methods, especially when used at low bit rates, introduce compression artifacts. Lossless compression methods may also be preferred for high value content, such as medical imagery or image scans made for archival purposes. Lossless or reversible compression refers to

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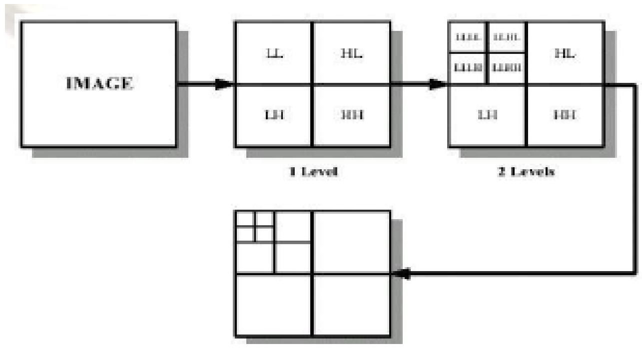
compression techniques in which the reconstructed data exactly matches the original. Lossless compression denotes compression methods, which give quantitative bounds on the nature of the loss that is
introduced. Such compression techniques provide the guarantee that no pixel difference between the original and the compressed image is above a given value. It finds potential applications in remote sensing, medical and space imaging, and multispectral image archiving. Many compression algorithms are there like entropy coding, huffmun coding, bit-plane coding, run lenth coding ,EZW(embedded zero tree wavelet), SPIHT (Set Partitioning in Hierarchal Trees), EBCOT (Embedded Block Coding with Optimal Truncation).

SPIHT is the wavelet based image compression method. It provides the Highest Image Quality, Progressive image transmission, fully embedded coded file, Simple quantization
algorithm, fast coding/decoding, completely adaptive, Lossless compression, Exact bit rate coding and Error protection.

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 tool for classical wavelet construction. Conventional method of discrete wavelet transform(DWT) refers to sub band coding using both high pass and low pass(1-D) filter banks.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 considerable resolution.In wavelet filter decomposition, these 1-D filter banks are converted to 2-D filter bank structures by successive sub-sampling operation. Below figure shows the wavelet filter sub band decomposition. The sub bands are labeled as LL,,HL,LH,HH respectively.[3][4]

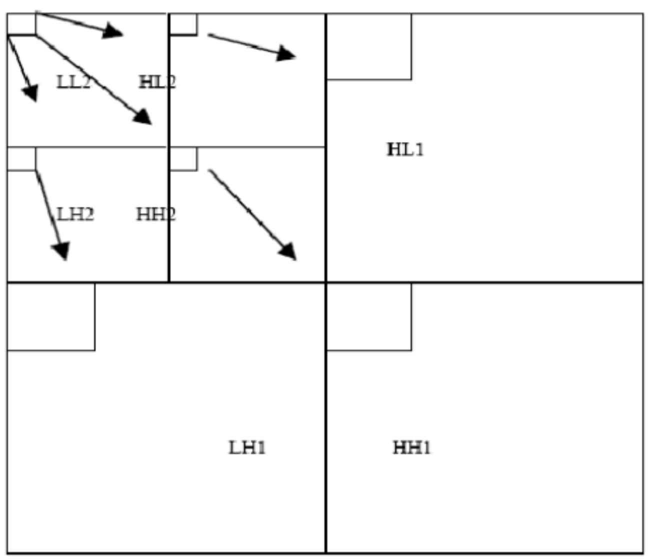
1. LL-Represents approximation content of the image resulting from low pass filtering in both horizontal and vertical directions.
2. HL- Represents vertical details resulting from vertical low pass filtering and horizontal high pass filtering.
3. LH-Horizontal details resulting from vertical high pass filtering and horizontal low pass filtering.
4. HH-Represents diagonal image details resulting from high pass filtering both vertically and horizontally.



Wavelet filter sub band decomposition

SPIHT CODER

The powerful wavelet-based image compression method called Set Partitioning in Hierarchical Trees (SPIHT). The SPIHT method is not a simple extension of traditional methods for image compression, and represents an important advance in the field. Extensive research has shown that the images obtained with wavelet-based methods yield very good visual quality. At first it was shown that even simple coding methods produced good results when combined with wavelets and is the basis for the most recently JPEG2000 standard. However, SPIHT belongs to the next generation of wavelet encoders, employing more sophisticated coding. In fact, SPIHT exploits the properties of the wavelet-transformed images to increase its efficiency.



Tree Structure of SPIHT

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SPIHT employs a parent child relation among the coefficients of the same orientation bands. For example, a coefficient in the LH3 band is the parent of 4 children in the LH2 band. Coefficients in the HL1, LH1, and HH1 bands have no children. Also, one of every four coefficients in the lowest resolution band has no children. Figure shows these parent-child relations. SPIHT codes the individual bits of the image wavelet transform coefficients following a bit-plane sequence. Thus, it is capable of recovering the image perfectly (every single bit of it) by coding all bits of the transform.

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 coordinates. 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. It is capable of recovering the image perfectly (every single bit of it) by coding all bits of the transform.

LIFTING SCHEME

The lifting scheme introduced by Sweldens[1] is a well-known method to create bi-orthogonal wavelet filters from other ones.

Filter banks are the fundamental tool to create discrete wavelet transforms.The problem of reconstruction of data from sub signals from each filter channel is removed by lifting scheme because this structure itself assures reversibility. If a pair of filters(h , g) is complementary i.e. it allows for perfect for perfect reconstruction then for every filter S the pair (h , g) with h'(z)=h(z)+s(z2).g(z) allows perfect reconstruction.

In lifting scheme the wavelet calculate the difference between prediction and actual value.

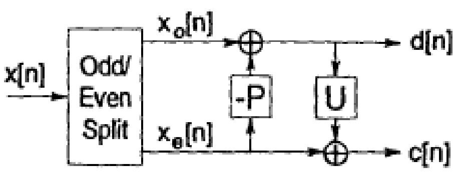

Figure 1: *Lifting stage: Split, Predict, Update.*

Split:- Divide the original data into two disjoin subsets. For

Example we will split the original data set xe[n] =x[2n],

the even indexed points and xo[n]=x[2n+1], the odd

indexed points.

Predict:- Generate the wavelet coefficients d[n] as the error in

Predicting xo[n] from xe[n] using prediction operator P

d [n]= xo[n] – P (xe[n])

Update:- Combine xe[n] and d[n] to obtain scaling coeffients

C[n] that represents a coarse approximation to the original signal x[n]. this is accomplished by an upate operator U to the wavelet coeffient and adding to xe[n].

C[n]= xe[n] +U (d[n])

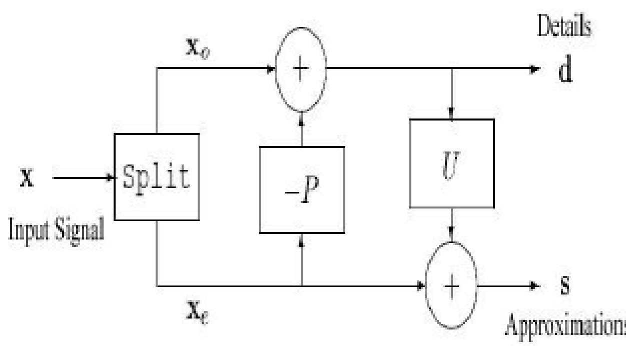

Fig. 2 .Forward Lifting Scheme

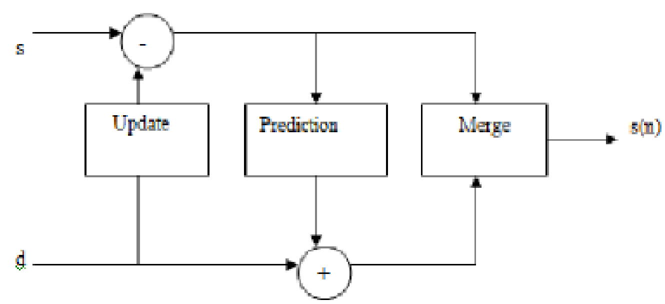

Fig.3 Inverse Lifting Scheme

A similar reverse operation is performed so as to restore the perfect original image by Inverse Lifting scheme.[6]The basic steps are-Update,Predict and Merge so as to perform inverse wavelet transform as shown is Fig.4.The signal s(n) is equal to the input original signal x .[7]

PROPOSED METHOD

In this proposed method lossless image compression is done. First the image undergoes for wavelet

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transform with wavelet 'cdf97', and compressed with SPIHT. Then the reverse lifting and decompression is done. The results are simulated for compression ratio , PSNR and RMSE.

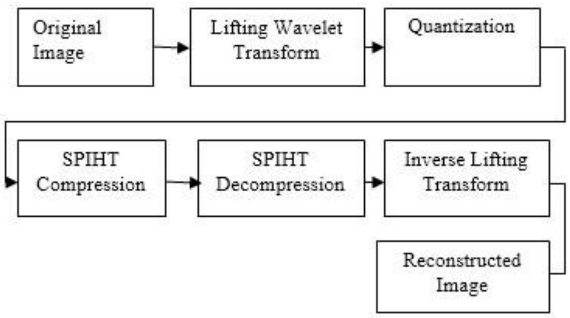

Fig.4 Block diagram of proposed work

SIMULATION RESULTS

Using MATLAB 7.10 ,simulations are performed for two levels of lifting scheme. The performance parameters like compression ratio, PSNR and RMSE are calculated for two different lifting levels.

The compression that achieved can be given by compression ratio by the following formula:

CR=n1/n2

Where n1 and n2 denote the information carring bits in the original image and compressed image respectively.

The PSNR (peak signal to noise ratio) is given by following formula:

PSNR= 20*log10(255²/MSE) db

And MSE (mean square error)is given by,

$$MSE = \frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}\left[f(x,y)-\hat{f}(x,y)\right]^2$$

The experimental results with proposed method have been arranged in the Table 1 and Table 2 for different images.

Table 1: Output for different images with LS

Image	PSNR in db	RMSE	Ealuation time with Lifting in Sec.
Image 1	52.714	0.5899	9.631
Image 2	54.107	0.5025	9.172
Image 3	52.984	0.5719	9.149
Image 4	54.395	0.4861	9.05
Image 5	54.184	0.5001	9.48

Table 1: Output for different images without LS

Image	PSNR in db	RMSE	Evaluation time without Lifting in Sec.	Ealuation time with SPIHT in Sec.
Image 1	44.86	1.46	43.083	9.631
Image 2	35.68	4.20	42.798	9.172
Image 3	31.75	6.59	42.659	9.149
Image 4	50.33	0.78	42.311	9.05
Image 5	41.80	2.07	43.630	9.48

From the table1 and table2 it is seen that the PSNR is significantly improved with lifting scheme. The transformed and the reconstructed image both are considered. These simulation results confirm to the fact that implementing the LS improves the compression parameters like PSNR,Compression ratio and RMSE. As we increase the SPIHT rate upto 1 we get better reconstruction. At rate equal to 1 we get perfect reconsruction.

CONCLUSION

In this paper, image compression model using the Lifting Scheme is projected and the simulation results gives the superior performance of such efficient compression model. The proposed lifting scheme provides the high compression ratio, high PSNR and minimum error. The processing speed is also minimum compared to the without lifting scheme. The implementation of Lifting Scheme along with SPIHT 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.

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