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Implementation of Advanced Image Compression using Wavelet Transform and SPHIT Algorithm

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Abstract

Since images will constitute a large part of future wireless data, we focus in this paper on developing energy efficient, computing efficient and adaptive image compression and communication techniques. Based on a popular image compression algorithm, namely, wavelet image compression. In this method I propose an implementation of discrete-time wavelet transform based image codec using Set Partitioning of Hierarchical Trees (SPIHT) coding in the MATLAB environment. The approach is based on discrete-time wavelet transform (DWT), which produces multi-scale image decomposition.

Keywords: Image Compression, Wavelets, SPIHT algorithm.

Introduction

When we speak of image compression, there are generally two different solutions, the lossless and lossy concept of operation. Lossy compression methods most often rely on transforming spatial image domain into a domain, that reveals image components according to their Relevance, making it possible to employ coding methods that take advantage of data redundancy in order to suppress it.

Since first attempts, the discrete cosine transform (DCT) domain has been used. Image is divided into segments (due to the fact DCT was designed to work with periodic states) and each segment is then a subject of the transform, creating a series of frequency components that correspond with detail levels of the image.

The other approach is based on discrete-time wavelet transform (DWT), which produces multi-scale image decomposition. By employing filtering and subsampling, a result in the form of the decomposition image is produced. These methods have resulted in practical advances such as: superior low-bit rate performance, continuous-tone and bit-level compression, lossless and lossy compression, progressive transmission by pixel accuracy and resolution, region-of-interest coding and others. One of the most efficient procedures that fullfil the above goals is the Set Partitioning in Hierarchical Trees (SPIHT)[1] algorithm. This algorithm bases its efficiency in key concepts like: a) partial ordering of wavelet coefficients by magnitude, with transmission of order by a subset partitioning that is replicated at the decoder, b) ordered bit-plane transmission of refinement bits and c) exploitation of self-similarity of the image wavelet coefficients across different scales.

Discrete Wavelet Transform & SPIHT

a) Discrete Wavelet Transform

The discrete wavelet transform (DWT)[2] refers to wavelet transforms for which the wavelets are discretely sampled. A transform which localizes a function both in space and scaling and has some desirable properties compared to the Fourier transform. The transform is based on a wavelet matrix, which can be computed more quickly than the analogous Fourier matrix. Wavelet compression is a form of data compression well suited for image compression (sometimes also video compression and audio compression). The goal is to store image data in as little space as possible in a file. A certain loss of quality is accepted (lossy compression).

A Wavelet system expansion can be written as the following

$$f(t) = \sum_{k=-\infty}^{\infty} \left(c_{j_0,k} 2^{\frac{j_0}{2}} \phi(2^{j_0} t - k) \right) + \sum_{k=-\infty}^{\infty} \left(\sum_{j=j_0}^{\infty} (d_{j,k}\, \psi(2^{j} t - k)) \right)$$

The Discrete Wavelet Transform can be described as a series of filtering and sub-sampling (decimating in time) as depicted in Figure 1. In each level in this series, a set of 2j−1 coefficients are calculated, where j < J is the scale and N = 2J is the number of samples in the input signal. The coefficients are calculated by applying a high-pass wavelet filter to the signal and down sampling the result by a factor of 2. At the same level, a low-pass scale filtering is also performed (followed by down-sampling) to produce the signal for the next level.

Since images are two-dimensional signals, we have to extend the scheme to 2D space by applying the transform row- and column-wise, respectively (taking separability of the transform into account). As a consequence four subbands arise from one level of the transform – one low-pass subband containing the coarse approximation of the source image called LL subband, and three highpass subbands that exploit image details across different directions – HL for horizontal, LH for vertical and HH for diagonal details. In the next level of the transform, we use the LL band for further decomposition and replace it with respective four subbands. This forms the decomposition image. An example can be observed in Fig. 2.

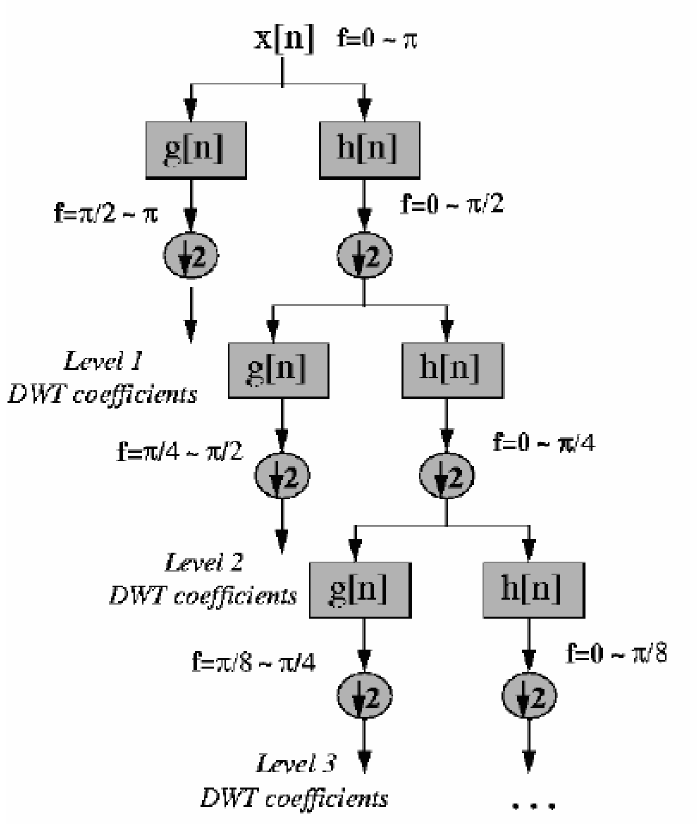
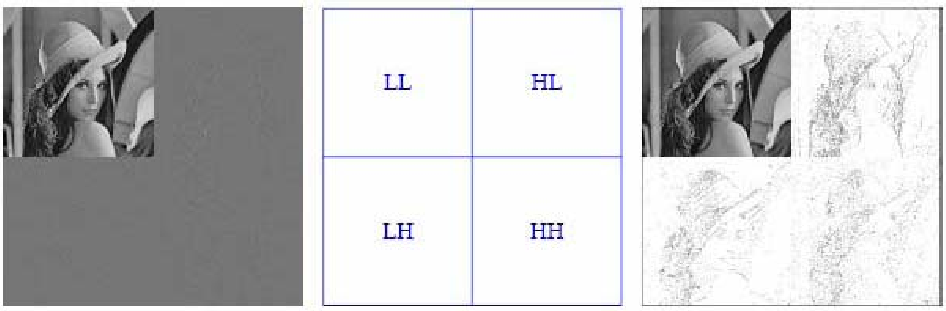


Figure 1



(a) CDF(2,2) wavelet applied as tensor product to the rows and columns of the image *lena*

(b) the different frequency blocks

(c) set all coefficients v in LH, HL, HH with $-20 < v < 20$ to white color

Figure 2

Wavelet Family includes several wavelets like Biorthogonal wavelet, Coiflet wavelet, Symlet , Haar wavelet etc.

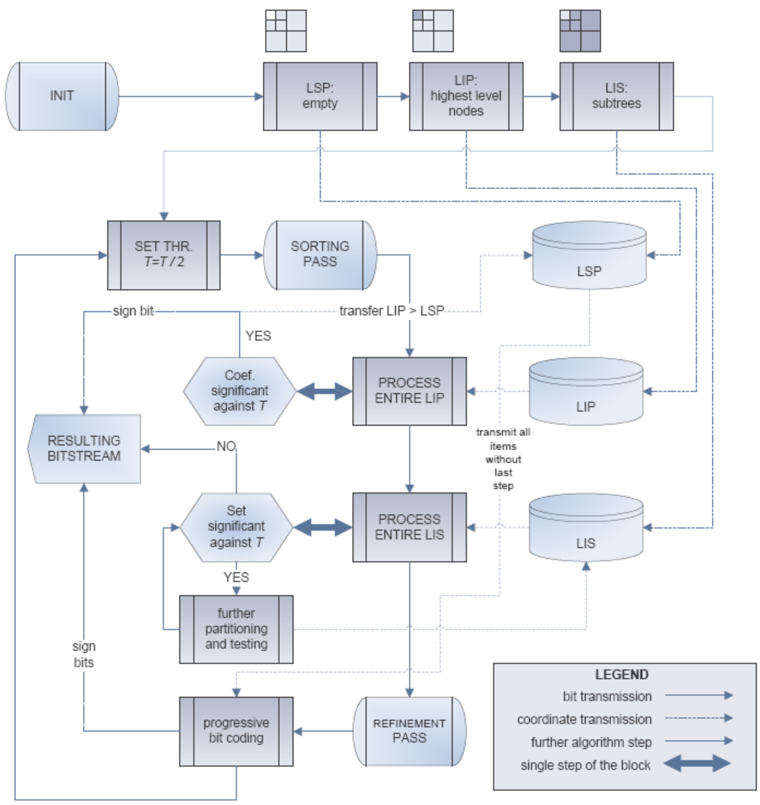
Here in this research work we propose a method to find the best wavelet transform and filter for different images which produces an optimum PSNR and compression ratio. Different types of wavelets are to be studied and to be implemented on different images with different rates (Sampling rate/ bits per pixel).Here we are making use of **SPHIT[1]** algorithm to compress an image. By using **wavelet transform** we can compress an image upto 85-90 % without sacrificing much with image quality and resolution, which is much better than older compression techniques.

SPIHT Algorithm

Said and Pearlman have significantly improved the codec of Shapiro. The main idea is based on partitioning of sets, which consists of coefficients or representatives of whole subtrees . The coefficients of a discrete wavelet transformed (DWT) image are classified into three sets. These sets are as given below:

1. The coordinates of those coefficients, which are insignificant with respect to the current threshold, are contained in the list LIP of insignificant pixels.
2. The coordinates of those coefficients, which are significant with respect to the current threshold, are contained in the list LSP of significant pixels.
3. The coordinates of the roots of insignificant subtrees are contained in the list LIS of insignificant sets. The sets of coefficients in LIS are refined during compression and if the coefficients become significant they are moved from LIP to LIS.

The complete algorithm for SPIHT algorithm is:



Observation and Results

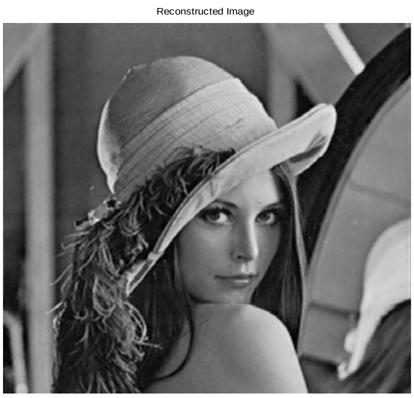
Results using Lena.jpg with constant Levels and varying Rates with no elimination of H, V or D components for Bior4.4[3] filter is:

S.No	Rate	Level	Elimination	PSNR	Compression Ratio
1	0.1	1	No	27.9184	90%
2	0.2	1	No	30.3460	80%
3	0.3	1	No	31.5333	70%
4	0.4	1	No	32.1411	60%
5	0.5	1	No	32.4258	50%
6	0.6	1	No	32.5926	40%
7	0.7	1	No	32.7509	30%
8	0.8	1	No	32.8291	20%
9	0.9	1	No	32.8861	10%

Original Image: Rate=8 bpp

Reconstructed Image: Rate=0.2, level=1, No elimination; PSNR=30.3460, CR=80%.

Reconstructed Image: Rate=0.6, Level=1, H components Eliminated,PSNR= 20.4006 , CR=40%



Reconstructed Image: Rate=0.9, Level=1, No Elimination PSNR=32.8861, CR=10%

References

[1] A. Said and W. A. Pearlman, "A New fast and efficient image codec based on set partitioning in hierarchical trees", IEEE Trans. On Circuits and Systems for Video Technology, vol. 6, no.3 pp 243-250, Jun. 1996.

[2] Daubechies "orthonormal bases of compactly supported wavelets,' Comm pure Appl. Mtah Vol 41, pp 909-966, 1998.

[3] S. M. Phoong, C. W. Kim, P. P. Vaidyanathan, and R. Ansari, "A new class of two-channel biorthogonal filter banks and wavelet bases", IEEE Trans. on signal Processing, vol. 43, no.3, pp. 649-665, Mar. 1995