Available online at www.elixirpublishers.com (Elixir International Journal)

Image Processing

Elixir Image Processing 53 (2012) 11880-11884

ISSN: 2229-712X

DTT based hybrid embedded coder for image compression using SPIHT algorithm

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ARTICLE INFO

Article history:

Received: 11 October 2012;
Received in revised form:
20 November 2012;
Accepted: 4 December 2012;

Keywords

Discrete Tchebichef Transform,
Discrete Cosine Transform,
Image Compression,
Embedded Coder.

ABSTRACT

The Discrete Tchebichef Transform (DTT) based on orthogonal Tchebichef polynomials can be an alternative to Discrete Cosine Transform (DCT) for JPEG image compression standard. The properties of DTT are not only very similar to DCT; it has also higher energy compactness and lower computational advantage using a set of recurrence relation. In this, DTT is coupled with Set partitioning in hierarchical coding techniques (SPIHT).It has been demonstrated that, DTT requires lesser number of bits to encode the coefficients than DCT for a given compression ratio. We present SPIHT which provides better performance than EZW .Later median filter is added in order to increase the PSNR and improve the quality the taken input image.

Introduction

We have different kinds of wavelet based image coders some of them are as follows: Embedded zero tree wavelet coder(EZW),Set partitioning in hierarchical trees(SPIHT), Morphological representations of wavelet data (MRWD) and significance-linked connected component analysis (SLCCA). These image coders provide excellent rate-distortion performances. Image Transform methods using orthogonal kernel functions are commonly used in image compression. One of the most widely known image transform method is Discrete Cosine Transform (DCT), used in JPEG compression standard. The computing devices such as Personal digital assistants (PDAs),digital cameras and mobile phones require a lot of image transmission and processing. Therefore, it is essential to have efficient image compression techniques, which could be scalable and applicable to these smaller portable devices.

A new class of transform called Discrete Tchebichef Transform (DTT), which is derived from a discrete class of popular Tchebichef polynomials, is a novel orthonormal version of orthogonal transform. It has found applications on image analysis and compression, recently DCT-based coders with innovative data organization strategies and representations of DCT coefficients had been reported with high of compression efficiency. Recently, DTT has been found excellent rate-distortion trade-off like DCT and outperforms DCT for image having high intensity graduations. Therefore, we propose to use DTT as substitute for DCT in an embedded coder. DTT and DCT exhibit similar energy compactness performance. It was very difficult to determine which of the two is better. Implementation of DCT requires integer approximation or intermediate scaling, like Integer cosines transform (ICT). The discrete Tchebichef transform (DTT) is another trans-form method using Tchebichef polynomials which has as good energy compaction properties as the DCT and works better for a certain class of images. Due to its high energy compaction property, the DTT has been used in image processing applications such as image compression and image feature extraction. The DTT has the additional advantage of requiring the evaluation of only algebraic expressions, whereas certain implementations of DCT require lookup tables for computing trigonometric functions.

The outline of paper is followed as: Section II describes explanation of image coding& types of embedded coders.. Section III gives review of the discrete Tchebichef transform algorithm. section Ivis discussed the properties of DTT & DCT The proposed DTT-SPIHT algorithm is presented in section V. section VI discusses the coding algorithm. section VII is discussed about Medina filter and noise removal Simulation and results analysis are presented in section VIII. Summary& Conclusion of paper in the last section.

Embedded Image Coding and types of embedded coders

The Shapiro's EZW coder exploits the self similarity of the wavelet transformed image across different scales by using hierarchical tree structure. The parent child relationships of a 3-level wavelet decomposition structure are featured in Fig.1.coefficient in LL_3 band (root), doesn't have any children. The coefficients in HL_3, LH_3 and HH_3 have four children each. A coefficient c_{ij} is called significant with respect to a given threshold T, if $|c_{ij}|\geq T$. if not it is insignificance. From the image statistics have shown that, if a wavelet coefficient is insignificant at a particular threshold T, it is very likely that it's descendents are insignificant with respect to the respective same threshold. There are several representatives of wavelet based image coders such as: Embedded zero tree wavelet coder (EZW), set partitioning in hierarchical trees (SPIHT), Morphological representations of wavelet data (MRWD) and Significance-linked connected component analysis (SLCCA).

An embedded image zero tree quantizer refines each input coefficients sequentially using a bitmap type of encoding

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scheme, and stops whenever the size of the encoded bit stream reaches exact target bit rate . By exploiting the parent child relationship across different scales in a wavelet coders can effectively order the coefficients by biplanes and transmit most significant information first. Therefore, it results an embedded bit stream with advantages like progressive transmission and precise rate control, which are absent in JPEG.

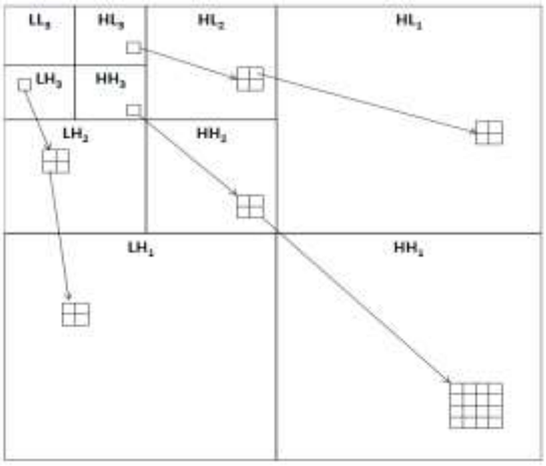


Fig.1 parent-child relationship of wavelet coefficients of 3-level wavelet decomposition pyramid

Discrete Tchebichef Transform

The Discrete Tchebichef Transform (DTT) is relatively a new transform that makes use of the Tchebichef moments to provide a basis matrix. As with DCT, the DTT is derived from the orthonormal Tchebichef polynomials [10].for size of image N×N, the forward Discrete Tchebichef Transform of order u+v id defined as:

$$T_{uv}=\sum_{x=0}^{N-1}\sum_{y=0}N^{-1}\, t_u(x)t_v(y)f(x,y) \qquad (1)$$

Where, u, v, x, y=0, 1, 2…N-1. The inverse transform of DTT is given by:

$$F(x,y)= =\sum_{u=0}^{N-1}\sum_{v=0}N^{-1}T_{uv}t_u(x)t_v(y) \qquad (2)$$

Where, u,v,x,y=0,1,2,…..N-1. From (1) and(2),$t_u(x)$ and $t_v(y)$ are u^{th} and v^{th} order Tchebichef polynomials. In general, nth order Tchebichef polynomial is defined using following relation as:

$$T_n=(A_1i+A_2)t_{n-1}(i)+A_3t_{n-2}(i) \qquad (3)$$

where,

$$A_1=2/n\ \sqrt{}\ (4n^2-1)/\ (N^2-1) \qquad (4)$$

$$A_2=1-N/n\ \sqrt{}(4n^2-1)/\ (N^2-1) \qquad (5)$$

$$A_3= n-1/n\ \sqrt{}(2n+1)/2n-3)\sqrt{}N^2-(n-1)^2/N^2-n^2 \qquad (6)$$

the initial value of $t_n(i)$ for n=0,1 is defined as:

$$t_0(i)=1/\sqrt{}n \qquad (7)$$

$$t_1(i)=(2i+1-N)/\sqrt{}3/N(N^2-1) \qquad (8)$$

Equ(2) can be expressed in series representation with matrices as follows:

$$F(x,y)= =\sum_{x=0}^{N-1}\sum_{y=0}N^{-1}T_{uv}G_{uv} \qquad (9)$$

Where, u, v, x, y=0, 1, 2…N-1. G_{uv} is called basis matrix. From Equa (9) defined as follows:

$$G_{uv}=\begin{pmatrix} t_u(0)+t_v(0) & t_u(0)+t_v(1) & t_u(0)+t_v(7) \\ t_u(1)+t_v(0) & t_u(1)+t_v(1) & t_u(1)+t_v(7) \\ \ldots\ldots & \ldots\ldots & \ldots\ldots. \\ t_u(7)+t_v(0) & t_u(7)+t_v(1) & t_u(7)+t_v(7) \end{pmatrix} \qquad (10)$$

Properties of DTT AND DCT

Some important characteristics of DTT are summarized as follows:

a. A discrete domain of definition which matches exactly with image coordinates space.

b. Absence of numerical approximation terms allows a more accurate representation of image features than others which is not possible using conventional transforms The compression performance, in terms of number of encoded bits and peak signal to noise ratio (PSNR) of the proposed system is compared with that of DCT based system. PROPERTIES OF DTT AND DCT as follows

A. Separability

The definition of DTT can be written in separable form as

$$T_{uv} = {}^{N-1}\sum_{x=0} t_u(x)^{N-1}\sum_{y=0}\ t_v(y)f(x,y) \qquad (11)$$

Therefore, it can be evaluated using two dimensional transforms as follows:

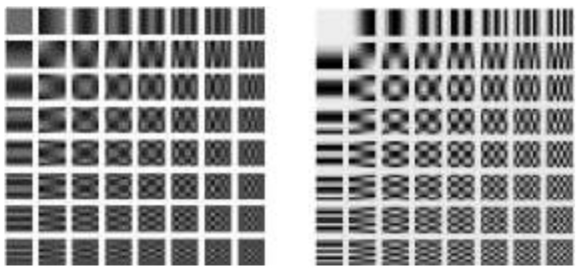
$$G_v(x)={}^{N-1}\sum_{y=0} t_v(y)f(x,y) \qquad (12)$$

$$T_{uv} = {}^{N-1}\sum_{x=0} t_u(x)g_v(x) \qquad (13)$$

B.Orthogonality

DTT and DCT basis functions are orthogonal. Therefore, this property renders some reduction in the pre-computation complexity. Fig. 1 (a) and (b) shows the 2-D basis images for the DTT and DCT

In the basis images, it has been observed that the low frequencies reside in the upper left corner of the spectrum, while the high frequencies are in the lower right. The basis functions for rows are increasing frequencies in horizontal directions while the basis functions for columns are increasing frequencies in vertical directions.



(a) (b)

Fig.1.Two dimensional Basis Image for (a) DTT, (b) DCT

C. ***Energy Compaction***

Efficiency of a transformation scheme can be gauged by its ability to pack input energy into as few coefficients as possible. Further, the quantizer discard coefficients with relatively small amplitudes without introducing visual distortion in the reconstructed image. DTT and DCT exhibit excellent energy compaction properties for highly correlated images. The energy of the image is packed into low frequency region (i.e. top left region).

Proposed DTT-SPIHT Method

The proposed DTT-SPIHT embedded coder is shown in Fig.2.The input image is divided into non-overlapping 8×8blocks.each block is transformed using discrete Tchebichef transform. Coefficients are arranged into 3level wavelet pyramid structure. Respective coefficients are quantized by SPIHT coding algorithm.

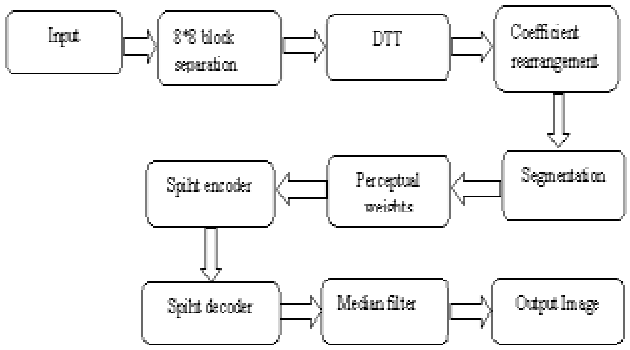


Fig.2. Block Diagram of DTT- SPIHT algorithm

Rearrangement Algorithm of Transformed Coefficients

Fig.3 shows the arrangement of 8×8DTT coefficients in a 3-level wavelet pyramid structure. After labeling 64 coefficients in each block the parent child relationship is defined as follows: the parent coefficient i is └i/4┘for 1≤ i≤63,{4j,4j+1,4j+2,4j+3}for 1≤ j≤15. The DC coefficient 0 is the root of TT coefficients tree, which has only three children: coefficient 1,2,3. In the same spatial location in the next finer band of the pyramid. A tree corresponds to a node having 4 children which always form a group of 2×2 adjacent pixels. In fig.3 arrow indicate that same index coefficients of other 8×8 blocks are grouped together.

In the proposed decomposition method, we further decompose LL_3 band into a 3-level so that coarsest level will be an 8×band.now overall decomposition is six. Now SPIHT algorithm is applied to overall structure.

0 1 2 3	4 5 6 7	16 17 20 21 18 19 22 23
8 9 10 11	12 13 14 15	24 25 28 29 26 27 30 31
32 33 36 37 34 35 38 39 40 41 44 45 42 43 46 47		48 49 52 53 50 51 54 53 56 57 60 61 58 59 62 63

⇩ Coefficients Rearrangement

0→ ↓	1→ ↓	4 5→ 6 7 ↓	16 17 20 21 18 19 22 23→ 24 25 28 29 26 27 30 31 ↓
2→ ↓	3→ ↓		
8 9→ 10 11 ↓		12 13→ 14 15 ↓	
32 33 36 37 34 35 38 39 → 40 41 44 45 42 43 46 47 ↓			48 49 52 53 51 51 54 53→ 56 57 60 61 58 59 62 63 ↓

Fig.3 Rearrangement algorithm of 8×8 transformed coefficients.

Perceptual weights

In the proposed coder, different perceptual weights have been added across the subbands. It is found that from research in vision psychophysics that sensitivity of human eyes to the distortion reduces in order from edge block. Different sensitivities suggest that different kinds of perceptual weights should be assigned to different blocks. These weights decrease from coarse to fine scale in accordance with energy decreasing characteristics of wavelet coefficients. most significant coefficients transferred with highest priority. by this we can improve the quality of reconstructed image. Table 1 shows the perceptual weights applied to high frequency sub-bands at coarsest scale. Segmentation process determines the type of image block. Entropy and variance values of different blocks play an important role during segmentation. The entropy value of smooth block of textured is similar than edge and smooth block.

SPIHT Algorithm

SPIHT is computationally very fast and among the best image compression algorithms known today. According to statistic analysis of the output binary stream of SPIHT encoding, propose a simple and effective method combined with Huffman encode for further compression. Wavelet transform as a branch of mathematics developed rapidly, which has a good localization property in the time domain and frequency domain, can analyze the details of any scale and frequency. so, it superior to Fourier and DCT. It has been widely applied and developed in image processing and compression. EZW stands for 'Embedded Zero tree Wavelet'. "Embedded Image Coding Using Zero trees of Wavelet Coefficients". EZW is a simple and effective image compression algorithm, its output bit-stream ordered by importance. Encoding was able to end at any location, so it allowed achieving accurate rate or distortion. This algorithm does not need to train and require pre-stored codebook.

Spiht Coding Algorithm

In 1996, Pearlman and Said improved the embedded zerotree wavelet (EZW) algorithm and developed a faster and more efficient image coding technology called set partitioning in hierarchical trees (SPIHT) (Shapiro, 1993; Said and Pearlman, 1996). SPIHT represents a step toward realizing lower costs with respect to compression complexity and prediction, as proposed in JPEG and JPEG 2000, to achieve higher compression performances (Pennebaker and Mitchell, 1993; Adams, 2001; Taubman, 2000; Pennebaker and Mitchell, 1988). In recent years, much research work has been done to improve (Zhu and Lawson, 2001; Weng and Areekul, 2003; Sun *et al*., 2002), or extend SPIHT (Pearlman *et al*., 2004; Hsiang and Woods,2001; Andrew, 1997). Zhu and Lawson (2001) suggested a new coding technique to improve SPIHT.

1) Initialization:

1. Output $n=[\log_2 \max\{|C(i,j)|\}]$;
2. Set LSP= Ø ;
3. Set LIP= (i,j) ∈ H;
4. Set LIS=(i,j) ∈ H, where D(i,j) ≠ Ø and set each entry in LIS as type A;

2)Sorting Pass:

2.1) for each entry (i, j) in the LIP do:
output Sn(i, j),
if Sn(i, j)=1 then move (i, j) to the LSP, and
output the sign of $c_{i,j.}$

2.2) for each entry (i, j) in the LIS do:

Table I
PSNR (db) Comparison of DTT-SPIHT

Rate (b/p)	DCT -SPIHT		DTT-SPIHT	
Images	256 Level - Test pattern	ruler	256 Level- Test pattern	ruler
0.125	17.3	13.0	17.3	13.8
0.25	19.1	16.3	19.0	19.3
0.50	21.8	22.9	21.8	23.1
0.75	24.4	26.5	24.5	27.4
1.00	26.6	28.6	26.8	31.0

Table II
Comparison of PSNR (dB) Values of DCT-SPIHT with DTT-SPIHT

Image	Barbara	Lena	Barbara	Lena
0.25	26.9	31.8	26.5	31.6
0.50	30.6	35.6	29.8	35.3
0.75	33.5	37.7	32.7	37.5
1.00	36.1	39.3	35.3	39.2

2.2.1) if the entry is of type A then
output Sn(D(i, j)),
if Sn(D(i, j)) = 1 then
* for each $(k,l) \in O(i,j)$ do:
output Sn(k, l),
if Sn(k, l) = 1 then
add (k, l) to the LSP, output the sign of $c_{k,l}$, if Sn(k, l)=0 then
add (k, l) to the end of the LIP,
*if $L(i,j) \neq 0$ then
move (i, j) to the end of the LIS, as an entry of type B, go to Step 2.2.2).
Otherwise remove entry (i, j) from the LIS,
2.2.2) if the entry is of type B
output Sn(L(i, j)),
if Sn(L(i, j)) = 1 then
*add each hm to the end of the LIS as an entry of type A,
*remove (i,j) from the LSP,
3) Refinement Pass:
For each entry (i, j) in the LSP, except those included in the last sorting pass (i.e., with the same n), output the *n*th most significant bit of | $c_{i,j}$ |;
4) Quantization Pass:
Decrement *n* by 1 and go to Step 2.

Median Flter

The median filter is normally used to reduce noise in an image, somewhat like the mean filter. However, it often does a better job than the mean filter of preserving useful detail in the image. Like the mean filter, the median filter considers each pixel in the image in turn and looks at its nearby neighbors to decide whether or not it is representative of its surroundings. Instead of simply replacing the pixel value with the mean of neighboring pixel values, it replaces it with the median of those values. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value. Here in this proposed scheme we use this filter for quality improvement and also to vary the PSNR & MSE values .by this we get fine quality of the input image.

Simulation Results And Analysis

To evaluate the performance of this proposed hybrid image coding algorithm, experiments are conducted on Lena, Barbara, 256 Level Test Pattern and Ruler images. Size of each image is 512 × 512.intially images is a smooth and second one is texture image, third and fourth are images having sharp edges.

Table I shows a comparison of proposed DTT-SPIHT algorithm with some of best known algorithm .on comparing with improved JPEG,DTT-SPIHT shows a PSNR reduction of 0.2dB for bit rates 0.5 and 0.3dB for bit rate 0.25bpp on Lena image. At bit rate above 0.75 the PSNR value of DTT-SPIHT is high. For Barbara image, DTT-SPIHT shows a PSNR reduction of 0.3dB between 0.5-0.75bpp.TheAdvantage of the proposed method is its simplicity in comparison with to improved JPEG .by incorporating arithmetic coding stages in the coder, additional 5-10 percentage compression can be achieved.

The performance of proposed DTT-SPIHT algorithm can be well judged from table III, which shows a PSNR comparison between DCT-SPIHT and DTT-SPIHT on 256 level test pattern and ruler images. It is seen that for bit-rates above 0.5 bpp DTT-SPIHT shows a gain of 0.1 to 0.2dB on 256 level test pattern image. Below 0.5 bit-rate, the PSNR gain is almost same. On ruler image, the proposed algorithm outperforms DCT-SPIHT at any bit-rates.

(a) (b)

Fig.3.Reconstructed images of Lena with DTT-SPIHT at bit-rate 0.25bpp (a), (PSNR=31.5) (b) HVS on (PSNR=31.6).

Conclusion

So finally we presented DTT-SPIHT Embedded image coder algorithm. It has been elaborated that proposed image coding algorithm shows a impressive PSNR gain over standard baseline JPEG, EZDCT but comparable with Improved JPEG, Texture images.foe sharp edges images DTT-SPIHT consistently out-performs DCT-SPIHT.by using. median filter is normally used to reduce noise in an image, somewhat like the mean filter.In this proposed scheme we use this filter for quality improvement and also to vary the PSNR & MSE values .by this we get fine quality of the input image This observed at bit rates between0.5 to 1bpp.further research is to adaptive HVS and modified SPIHT algorithm by expected to improve the quality of image at low bit rates. This we can implent for the video compression.

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