A Novel Image Coding Algorithm Using DTT and SPIHT

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Abstract

In recent years, most of the research activities are focused on wavelet based image coders rather than DCT based image coders. This is mainly attributed due to innovative strategies of data organization and representation of wavelet transformed coefficients. This paper presents a Discrete Tchebichef Transform (DTT) based hybrid image coder for image compression applications. In this coder DTT is coupled with set partitioning in hierarchical coding techniques (SPIHT).The compression and image reconstruction performance is compared with existing coders..

1. Introduction

Data compression has become an area of great interest in comparing due to the limited data storage and Network capabilities. In recent years, most of the research activities are focused on wavelet based image coders rather than DCT based image coders. This is mainly attributed due to innovative strategies of data organization and representation of wavelet transformed coefficients. The Discrete Cosine Transform (DCT) is a transform method on discrete signals and used in many signal processing applications including JPEG image compression standard.

A new class of transform known as Discrete Tchebichef Transform (DTT) is another transform method introduced recently and based on the orthogonal version of Tchebichf polynomials. It has been shown that the DTT has a good energy compaction property, performs as well as the DCT for many images and performs better for certain classes of images. It is that the good energy Compaction property will allow describing major feat of images by relatively few numbers of values. The image compression based on the DTT will have a good image compression ratio and compress images as quickly as possible.DTT has been found excellent rate-distortion trade off like DCT

and out performs DCT for image having high intensity graduations. Therefore we implemented to use DTT as a substitute for DCT in an image coder. The implemented image coder consists of DTT and SPIHT coding technique. The performance of this kind of coder is evaluated and is compared with DCT based image coders, JPEG, improved JPEG; it has found that the implemented coder best performs most of the coders.

2. Image Coding

Fig.1Illustigration of 3level wavelet Decomposition

The image coder is similar to the wavelet transformed image across different scales by using a hierarchical tree structure.1-D set of samples are converted into the low-pass sub-band (Li) and high pass sub-band (Hi).The low pass sub-band represents a down sampled low resolution version of the original image. 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.

The 1-D wavelet transform can be extended to a two dimensional (2-D) wavelet transform using separable wavelet filters. With separable filters the 2-D transform can be computed by applying a 1-D transform to all the rows of the input, and then repeating on all of the columns.

The example is repeated for a Three-Level (k=3) wavelet expansion in fig:1. In all of the discussion k represents the highest level of the wavelet transform.

The 2-D sub-band decomposition is just an extension of 1-D sub-band decomposition. The entire process is carried out by executing 1-D sub-band decomposition twice, first in one direction (horizontal), then in the orthogonal (vertical) direction. For example, the low passes sub-band (Li) resulting from the horizontal direction is further decomposed in the vertical direction, leading to LLi and LHi sub-bands.

3. Discrete Tchebichef Transform

The Discrete Tchebichef Transform (DTT) is a linear transform with the kernel defined by the orthogonal version of Tchebichef polynomials. That the DTT has higher energy compactness that the DCT in images that have high illumination value variations such as artificial diagrams. The family of the DTT is also used in the field of image feature extraction.

The DTT is defined as follows Given a two dimensional input f(x,y) of site N*N,the transformed coefficients, Tpq of the two dimensional discrete Tchebichef Transform is defined as follows

$$T_{pq} = \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} t_p(x)\, t_q(y)\, f(x,y)$$

The kernel is

$$t_p(x) = (\propto_1 x + \propto_2) t_p(x) + \propto_3 t_{p-2}(x)$$

Where

$$t_0(x) = \frac{1}{\sqrt{N}}$$

$$t_1(x) = (2x+1-N)\sqrt{\frac{3}{N(N^2-1)}} \quad \text{and}$$

$$\propto_1 = \frac{2}{p}\sqrt{\frac{4p^2-1}{N^2-p^2}}$$

$$\propto_2 = \frac{1-N}{p}\sqrt{\frac{4p^2-1}{N^2-p^2}}$$

$$\propto_3 = \frac{1-p}{p}\sqrt{\frac{2p+1}{2p-3}}\sqrt{\frac{N^2-(p-1)^2}{N^2-p^2}}$$

Given Transformed coefficients T of the Two dimensional DTT of an N*N input f. The inverse Two dimensional DTT is defined as follows:

$$f(x,y) = \sum_{p=0}^{N-1} \sum_{q=0}^{N-1} t_p(x)\, t_q(y)\, T_{pq}$$

4. Image Compression Using DTT-SPIHT

The implemented DTT-SPIHT embedded coder is shown in Fig.2.The input image is divided into non-overlapping 8*8 block. Each block is transformed using discrete tchebichef transform. The coefficients are arranged into 3 level wavelet pyramid structure. The coefficients are quantized by SPIHT coding algorithm. The next stage is to use entropy coding which is optional. The proposed algorithm does not use entropy coding. used by our algorithm. By incorporating arithmetic coding stages in our coder, additional 5-10 percentage compression can be achieved.
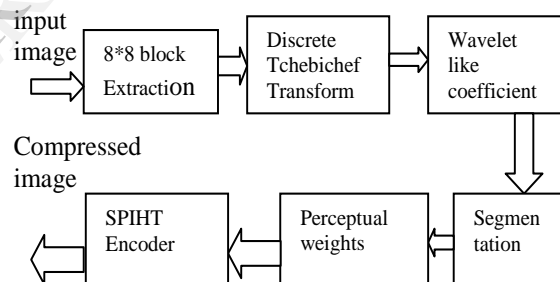

Fig:2. Block diagram of DTT-SPHIT Image coder

The arrangement of 8*8 DTT 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 of coefficient i is [i/4] for 1≤ i ≤63, while the set of four children associated with coefficient j is { 4j,4j+1,4j+2,4+3 } for 1≤ j ≤ 15.The DC coefficient 0 is the root of DTT coefficients tree, which has only three children: coefficients 1,2 and 3.In the proposed structure, off springs corresponds to direct descendants in the same spatial location in the next finer band of the pyramid. A tree corresponds to a node having four children which always form a group of 2*2 adjacent pixels. In Fig.3 indicate that the index coefficients of other 8*8 blocks are grouped together so that the entire Image can form an overall 3-level pyramid structure. In the implemented decomposition

method, we further decompose LL_3 band into a 3- level pyramid so that, the coarsest level will be a 8x8 band .the overall level of decomposition is now fix. Then SPIHT encoding algorithm is applied to the overall structure.

0 1	4 5	16 17 20 21
2 3	6 7	18 19 22 23
8 9	12 13	24 25 28 29
10 11	14 15	26 27 30 31
32 33 36 37		48 49 52 53
34 35 38 39		50 51 54 55
40 41 44 45		56 57 60 61
42 43 46 47		58 59 62 63

Fig.3. Rearrangement algorithm of 8x8 transformed coefficients.

SPIHT algorithm keeps track of the state of sets by means of three lists, i.e., list of insignificant sets(LIS). List of significant pixels (LSP) and lists of insignificant pixels(LIP).The algorithm uses the following sets to code a bitmap effectively(i,j) is the set of coordinates of all offspring's of node (i,j), D(i,j) is set of coordinates of all descendents of node (i,j), L(i,j) is the set of coordinates defined as D(i,j)-O(I,j), H(I,j) is set of all three roots. The significance test of the a wavelet coefficient is defined as follows

$$S_n(T) = \begin{cases} 1, (i,j \in T) \rceil T(i,j) \rceil \geq 2^n \\ 0, otherwise \end{cases}$$

Where, T(I,j) is the coefficient at node (I,j).T is the testing coordinate set..Briefly, SPIHT coding method is described in the following two passes:

Initialization: LSP contains no elements (empty). LIP contains all tree roots at coarsest scale.LIS contains all tree nodes; choose the threshold according to $S_n(T)$.

- Sorting pass: output $S_n(I,j)$ for all the nodes (I,j) of LIP. If $S_n=1$, move the node (I,j) to the LSP and output the sign of T (I,j). for all the nodes belongs to type A. output $S_n(D(I,j))$. If $S_n(D(I,j))=1$, output $S_n(K,L)$ for any node (k,l) € O(I,j).
  If $s_n(k,l)=1$, append node (k,l) to the LSP and output its sign. Otherwise, move (k,l) to the LIP. If L (I,j)≠ϕ, then move (I,j) from LIS,

while marking as type B. otherwise, remove the node (I,j) from LIS. If the node belongs to type B, then output $S_n(L(I,j))=1$, append the fore direct subsequent nodes to the LIS as type A.

- Refinement pass: For each element (i,j) in the LSP, output the n-th most significant bit except those added above.
- Update: Decrement n by 1, and go to sorting pass.

5. Simulation Results

To evaluate the performance of hybrid image coding algorithm, experiments are conducted on Lena image. The size of image is 512x512.Input image to DTT-SPIHT algorithm is shown in fig .4.(a). After performing the DTT-SPIHT algorithm we obtained the compressed Lena image is shown in fig.4.(b). With compression ratio is 29.3166. The compressed Lena image is applied to inverse DTT-SPIHT we obtained the reconstructed Lena image is shown in fig.4. (c). With PSNR is42.845dB and MSE is 3.3772.Some of the best known algorithms in the literature. Comparing with improvised JPEG, DTT-SPIHT shows a high PSNR on Lena image. Advantage of the DTT-SPIHT method is its simplicity in comparison to improved JPEG. Entropy encoding and decoding processes are no DTT-SPIHT shows a good PSNR gain over existing image compression schemes on Lena image. DTT-SPIHT always performs the better than DCT-SPIHT scheme for Lena image.

The performance DTT-SPIHT algorithm shows a high PSNR compared with DCT-SPIHT.

Fig.4. (a) Input Image

Fig.4. (b).Compressed Image

Fig.4. (c).Reconstructed Image

6. Conclusion

DTT-SPIHT image coding scheme is implemented. It has been demonstrated that the implemented image coding algorithm shows an impressive PSNR gain over standard baseline Image compression standards on Lena image. For image having sharp edges, DTT-SPIHT consistently performs better than DCT-SPIHT. Future research direction is to use adaptive HVS and modified SPIHT algorithm, which is expected to improve the image quality at low bit-rates both subjectively and objectively

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