IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Set Partitioning in Hierarchical Trees (SPIHT)

Miss. Snehal C.Mane[*1], Dr.Mrs.S.R.Chougule[2]
[*1,2] BVCOE, Kolhapur 416004, Maharashtra, India
snehalmane11@gmail.com

Abstract

A very effective and computationally simplest technique for image compression is Embedded Zerotree Wavelet(EZW)coding. here we defined an alternative principle of an operation of image compression. these principles are partial ordering by magnitude with a set partitioning sorting algorithm, ordered bit plane transmission, and exploitation of self-similarity across different scales of an image wavelet transform. We present a new and different implementation based on set partitioning in hierarchical trees(SPIHT),which provides better performance than Embedded Zerotree Wavelet. SPIHT algorithm is used for source coding of an image to be transmitted. The image coding result, calculated from actual size and images reconstructed by decoding algorithm. In addition, the new coding and decoding procedures are extremely fast, and they can be made even faster, with only small loss in performance, by omitting entropy coding of the bit stream by arithmetic code.

Keywords: EZW(Embedded Zerotree Wavelet), SPIHT(set partitioning in hierarchical trees)

Introduction

Image compression technique is especially nonreversible or lossy ones have been known to grow computationally more complex as they grow more efficient, confirming the tenets of source coding theorems in information theory.EZW is a image coding technique which is introduced by Shapiro, interrupted the simultaneous progression of efficiency and complexity. This technique is not only was competitive in performance with most complex technique but also was extremely fast in execution and produced an embedded bit stream.

In this section we explain that the EZW technique. these technique is based on three concepts:

1) Partial ordering of the transformed image element by magnitude, with transmission of order by a subset partitioning algorithm that is duplicated at the decoder.
2) Ordered bit plane transmission of refinement bits Scales.

We say that an element is significant or insignificant with respect to a given threshold, depending on whether or not it exceeds that threshold.

The SPIHT algorithm has been introduced by Said and Pearlman [1]. It is algorithm based on the wavelet transform, and restricts the necessity of random access to the whole image to small sub images. The principle of the SPIHT is partial ordering by magnitude with a set partitioning sorting algorithm, ordered bit plane transmission, and exploitation of self similarity across different scales of an image wavelet transform. The success of this algorithm in compression efficiency and simplicity makes it well known as a benchmark for embedded wavelet image coding. The SPIHT is used for image transmission over the OFDM system in several research works because the SPIHT has a good rate-distortion performance for still images with comparatively low complexity and it is scalable or completely embeddable.

Arithmetic coding of the bit streams was essential to compress the ordering information as conveyed by the result of the significance tests. Here, the subset partitioning is so effective and the significance information so compact that even binary uncoded transmission achieves the better performance. Arithmatic coding can reduced mean sequared error and increases the peak to average ratio. Execution time are also reported to indicate the rapid speed of the encoding and decoding algorithms. The encoding algorithms can be stopped at any compressed file size or let run until the compressed file is a representation of an nearly lossless image.we say nearly lossless because the compression may not be reversible,as the wavelet transform filters,chosen for lossy coding,have noninteger tap weights and produce noninteger transform coefficients,which are trucated to finite precision.For perfectly reversible compression,one must use an integer multiresolution transform, such as the S+P transform, which yields excellent reversible compression results when used with the new extended EZW technique.

SPIHT Algorithm

The SPIHT algorithm defines and partitions sets in the wavelet decomposed image using a special data structure called a spatial orientation tree. A spatial orientation tree is a group of wavelet coefficients organized into a tree rooted in the lowest frequency (coarsest scale) subband with offspring in several generations along the same spatial orientation in the higher frequency subbands. In essence it uses a sub-band coder, to produce a pyramid structure where an image is decomposed sequentially by applying power complementary low pass and high pass filters and then decimating the resulting images. These are one-dimensional filters that are applied in cascade (row then column) to an image whereby creating a four-way decomposition: LL (low-pass then another low pass), LH (low pass then high pass), HL (high and low pass) and finally HH (high pass then another high pass). The resulting LL version is again four-way decomposed, as shown in Figure 1. This process is repeated until the top of the pyramid is reached.

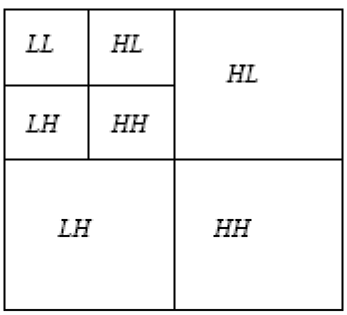

Fig1:Image decomposition using wavelet.

This algorithm exists parent children dependancy and it exits the following relationship

Parent=(i,j) (i)

children = [(2i,2j),(2i + 1,2j),(2i,2j + 1),(2i + 1,2j + 1)] (ii)

Spatial Orientation Trees

Most of an image's energy is concentraced in the low frequency components.Consequently,the varience decreses as we move from the highest to the lowest levels of the subband pyramid .Furthermore, it has been observed that there is a spatial self-similarity between subbands,and the coefficients are expected to be better magnitude-ordered if we move downword in the pyramid following the same spatial orientation.

A tree structure,called spatial orientation tree,naturally defines the spatial relationship on the hierarchical pyamid.spatial orientation tree is defined in a pyramid constructed with recursive four – subband splitting. Each node of the tree corresponds to a pixel and is identified by the pixel cordinate.its direct desendants (offspring) correspond to the pixel of the same spatial orientation in the next finer level of the pyamid,the tree is defined in such a way that each node has no offspring (the leaves) or four offspring,which always from a group of 2 by 2 adjacent pixels.

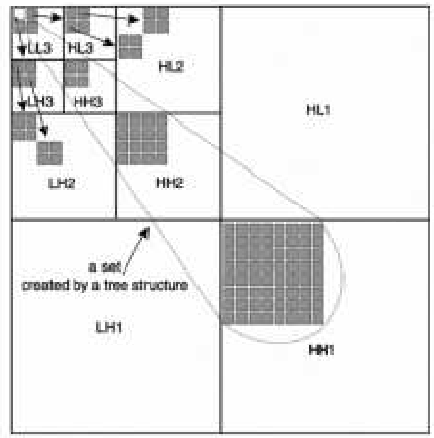

Fig2: Parent children dependency &spatial orientation of subband tree across wavelet.

The basic principle is the same; a progressive coding is applied, processing the image respectively to a lowering threshold. The difference is in the concept of zerotrees (spatial orientation trees in SPIHT). This is an idea that takes bounds between coefficients across subbands in different levels into consideration. The first idea is always the same: if there is an coefficient in the highest level of transform in a particular subband considered insignificant against a particular threshold, it is very probable that its descendants in lower levels will be insignificant too, so we can code quite a large group of coefficients with one symbol.

Stages of SPIHT Algorithm

The SPIHT algorithm consists of three stages: initialization, sorting and refinement. It sorts the wavelet coefficients into three ordered lists: the list of insignificant sets (LIS), the List of Insignificant Pixels (LIP), and the List of Significant Pixels (LSP). At the initialization stage the SPIHT algorithm first defines a start threshold based on the maximum value in the wavelet pyramid, then sets the LSP as an empty list and puts the coordinates of all coefficients in the coarsest level of the wavelet pyramid (Le. the lowest frequency band; LL band) into the LIP and those which have descendants also into the LIS. In the sorting pass, the algorithm first sorts the elements of the LIP and then the sets with roots in the LIS. For each pixel in the LIP it performs a significance test against the current threshold and outputs the test result to the output bit stream. All test results are encoded as either 0 or 1, depending on the test outcome, so that the SPIHT algorithm directly produces a binary bitstream. If a coefficient is significant, its sign is coded and its coordinate is moved to the LSP. During the sorting pass of LIS, the SPIHT encoder carries out the significance test for each set in the LIS and outputs the significance information. If a set is significant, it is partitioned into its offspring and leaves. Sorting and partitioning are carried out until all significant coefficients have been found and stored in the LSP .After the sorting pass for all elements in the LIP and LIS, SPIHT does a refinement pass with the current threshold for all entries in the LSP, except those which have been moved to the LSP during the last sorting pass. Then the current threshold is divided by two and the sorting and refinement stages are continued until a predefined bit-budget is exhausted. It uses the basic principle that if the execution path of any algorithm is defined by the results on its branching points, and if the encoder and decoder have the same sorting algorithm then the decoder can recover the ordering information easily

To take advantage of the spatial relationship among the coefficients at different levels and frequency bands, the SPIHT coder algorithm orders the wavelets coefficient according to the significance test defined as:

$$\max_{(i,j) \in \tau_m} \left|C_{i,j}\right| \geq 2^n \qquad \text{(iii)}$$

where *Ci,j* is the wavelet coefficient at the nth bit plane, at location (i,j)of the ,τm subset of pixels, representing a parent node and its descendants. If the result of the significance test is yes an S flag is set to 1 indicating that a particular test is significant. If the answer is no, then the S flag is set to 0, indicating that the particular coefficient is insignificant. This is represented by equation

$$S_n(\tau) = \begin{cases} 1, & \max_{(i,j) \in \tau} \left|C_{i,j}\right| \geq 2^n \\ 0, & \text{otherwise} \end{cases} \qquad \text{(iv)}$$

Wavelets coefficients which are not significant at the nth bit-plane level may be significant at (n-1)th bit-plane or lower. This information is arranged, according to its significance, in three separate lists: list of insignificant sets (LIS), the list of insignificant pixels (LIP) and the list of significant pixels (LSP).

The SPIHT algorithm can be summarized as follows

1. **Initialization**:Output n= $n = \left\lfloor \log_2 (\max_{(i,j)} \left\{\left|C_{i,j}\right|\right\} \right\rfloor$;
   set the LSP as empty list and add the coordinates H to the LIP and only those with descendents also to the LIS, as type A entries.
2. **Sorting Pass :**
   2.1 for each entry (i,j) in the LIP do:
   2.1.1 Output *Sn(i ,j)*
   2.1.2 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:
   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)∈O((i ,j)do:
   o Output Sn(k,l)
   o If Sn(k,l)=1 then add (k,l)to the LSP and output the sign of Ck,l
   o If Sn(k,l)=0 then add (k,l) to the end of LIP
   * If L (i,j) ≠ φ then move to the end of the LIS as entry of type B, and go to step 2.2.2; otherwise remove entry from the LIS:
   2.2.2 if the entry is of type B then
   • Output Sn(L(i ,j))
   • If Sn(L(i ,j)) then
   * add each(k,l)∈O(i ,j) to the end of the LIS as entry of type A
   * remove(i,j) from the LIS
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 nth most significant bit of |Cij|
4. **Quantization step update**: decrement n by 1 and go to step 2

Notations used in the algorithm are defined as follows:
O(i,j): set of coordinates of the off-spring (i,j)
D(i,j): set of coordinates of all descendants (i,j)
H(i,j): set of coordinates of all tree roots in the highest level of the pyramid
L(i,j)=D(i,j)-O(i,j)

Simulation Results: The fidelity was measured by the Peak Signal-to-Noise Ratio, PSNR, which usually expressed in terms of the logarithmic scale. It can bedefined as follows:

$$PSNR = 10\log_{10}\left(\frac{Peak^2}{MSE}\right)$$

where, MSE is the mean squared error between the original and the reconstructed image, and Peak is the maximum possible magnitude for a pixel inside the image.we can calculate PSNR at different rates with different filters.

SPIHT Rate	PSNR with Bior 1.5	PSNR with Bior 4.4	PSNR with db2	PSNR with db15
0.5	34.42	37.01	35.41	36.03
1	39.13	57.38	40.77	40.11
1.9	81.79	61.69	48.04	46.79
2	83.58	61.74	48.75	60.25

Table1: PSNR calculations at different SPIHT rates.

In above table we have shows PSNR calculations at different rates with different filters .Image quality is depends upon PSNR values. High PSNR improves the quality of image. we can used the different decomposition levels.

Fig3:original image

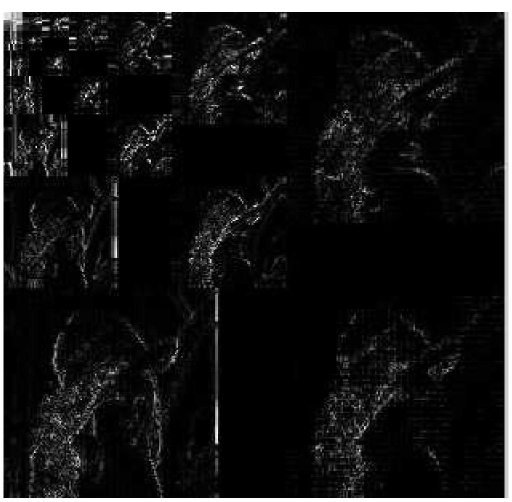

Fig 4: Pyramid tree generated by the four-way decomposition.

Fig 5: Recovered image at 5th level

Conclusion

We have presented an algorithm that operates through an set partitioning in hierarchical trees(SPIHT) and accomplishes completely embedded coding. This algorithm uses the principles of partial ordering by magnitude, set partitioning by significance of magnitudes with respect to a sequence of octavely decreasing thresholds, ordered bit plane transmission and self-similarity across scales in an image wavelet transform .

References

[1] Said, W.A. Pearlman: *A New Fast and Efficient Image Codec Based on Set Partitioning in Hierarchical Trees*, IEEE Transactions on Circuits and Systems for Video Technology, vol. 6,1996.

[2] S. H. Yang, Y. L. Chang, H. C. Chen: *A Digital Watermarking Scheme Based on SPIHT coding*, IEEE International Conference on Multimedia and Expo (ICME'01), pp. 441-444, 2001 3 J.M. Shapiro, "Embedded image coding using zero-trees of wavelet coefficients," IEEE Transactions Signal Processing, vol. 41, Dec. 1993.

[3] D. Taubman, "High Performance scalable image compression with EBCOT," IEEE Transactions on Image Processing, vol. 9, July 2000.

[4] A. A. Kassim, W. S. Lee: *Embedded Color Image Coding Using SPIHT With Partially Linked Spatial Orientation Tree*, IEEE Transactions on Circuits and Systems for Video Technology, vol. 13, pp. 203-206, 2003.

[5] S. H. Yang, Y. L. Chang, H. C. Chen: *A Digital Watermarking Scheme Based on SPIHT coding*,IEEE International Conference on Multimedia and Expo (ICME'01), pp. 441-444, 2001.

[6] D. Taubman, “High Performance scalable image compression with EBCOT,” IEEE Transactions on Image Processing, vol. 9, July 2000.