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Analysis of Wavelet Based Image Compression Technique : A Survey

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ABSTRACT

This Paper discuss the lossless compression techniques where the decompress image is exact replica of original image. Compression technique is useful where the size of image is very large. In this paper two techniques are discussed first is SPIHT and second one is JPEG2000. Both techniques are scene based and SPIHT gives better result where image is smooth means image variations are less in comparision to JPEG2000.

Keywords: SPIHT, JPEG2000, EBCOT, CDF

I. INTRODUCTION

With the advancement of technology the data become bulky and transmission of such a bulky data is very difficult the solution of this technique is image compression. The objective of compression is to reduce the number of bits as much as Possible, while keeping the resolution and the visual quality of the reconstructed image as close to the original image as possible. Compression achieved by the removal of one of the three basic redundancies Coding Redundancy, Spatial and/or Temporal/Interpixel Redundancy, Psychovisual, [1]. An inverse process called decompression (decoding) is applied to the compressed data to get the reconstructed image.

The image compression techniques are broadly classified into two categories depending whether or not an exact replica of the original image could be reconstructed using the compressed image. These are:Lossless technique where the decompressed image is exactly similar to original image andLossy technique where reverse is happens[2].

In this paper we deal with Wavelet based techniques viz. JPEG 2000 and Set Partitioning in Heirarchichal Tree (SPIHT) which is lossless by nature.

II. Different Techniques

A. Wavelet

Unlike the Fourier a transform, whose basis functions are sinusoids, wavelet transform based on small waves, called wavelets, of varying frequency and limited duration [3] .

Sinusoidal wave is one of the popular waves, which extend from -∞ to +∞. Sinusoidal signals are smooth and predictable; it is the basis function of Fourier analysis. Fourier analysis consists of breaking up a signal into sine and cosine waves of various frequencies. A wavelet is waveform of limited duration that has an average value of zero. Wavelets are localized waves and they extend not from -∞ to +∞ but only for finite time duration[4,5].

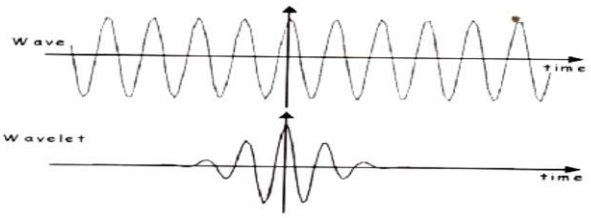

Figure 1: Wave and wavelet

B. JPEG 2000

JPEG2000 makes use of the wavelet and sub-band technologies. The core compression algorithm is primarily based on the Embedded Block Coding with Optimized Truncation (EBCOT) of the bit-stream. The EBCOT algorithm provides a superior compression

performance and produces a bitstream with features such as resolution and SNR scalability and random access [6].

III. Basic Architecture of the JPEG2000

The block diagram of the JPEG2000 encoder is illustrated in Fig. la. The biorthogonal CDF 5/3 wavelet transform is first applied on the source image data. The transform coefficients are then quantized and entropy coded, before forming the output code stream (bitstream). The decoder is the reverse of the encoder (Fig. 3.6). The code stream is first entropy decoded, dequantized and inverse discrete transformed, thus resulting in the reconstructed image data[7,8].

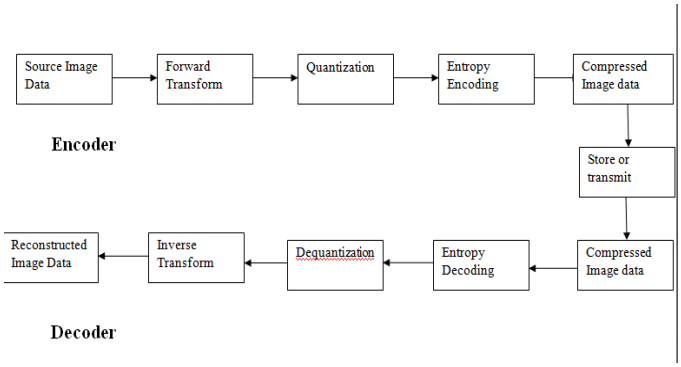

Figure 2. Basic Architecture of JPEG2000

IV. SPIHT

This algorithm was introduced by Amir Said and William A Pearlman in1996 (A.said and W.A.Pearlman, 1996). By using this algorithm, the highest PSNR values for given compression ratios for a variety of images can be obtained. SPIHT was designed for optimal progressive transmission, as well as for compression. SPIHT stands for *Set Partitioning in Hierarchical Trees[9]*.

This coding algorithm uses three lists called List of Significant Pixel (LSP), List of Insignificant Pixels (LIP), List of insignificant Sets (LIS) [10].The SPIHT algorithm is unique in that it does not directly transmit the contents of the sets, the pixel values, or the pixel coordinates. What it does transmit is the decisions made in each step of the progression of the trees that define the structure of the image. The advantage to this is that the decoder can have an identical algorithm to be able to identify with each of the decisions and create identical sets along with the encoder [11]. One of the important features of SPIHT is that at any point during the decoding of an image, the quality of the displayed image is the best that can be achieved for the number of bits input by the decoder up to that moment

SPIHT Algorithm [9,11]

We use the following function to indicate the significance of a set of coordinates and use the following sets of coordinates as defined in the SPIHT:

$$S_n(X) = \begin{cases} 1, & \max_{(i,j)\in X}\{|c_{i,j}|\} \geq 2^n \\ 0, & others \end{cases} \quad (1)$$

The following sets can represent the corresponding tree representations:

O(i,j): set of coordinates of all offspring of node (i,j); *children only*
D (i,j): set of coordinates of all descendants of node (i,j); *children, grandchildren, great-grand, etc.*
H (i,j): set of all tree roots (nodes in the highest pyramid level); *parents*
L (i,j): **D** (i,j) – **O**(i,j) (all descendents except the offspring); *grandchildren, great-grand, etc.*

The following are the lists that will be used to keep track of important pixels:

LIS: List of Insignificant Sets, this list is one that shows us that we are saving work by not accounting for all coordinates but just the relative ones.
LIP: List of Insignificant Pixels, this list keeps track of pixels to be evaluated
LSP: List of significant Pixels, this list keeps track of pixels already evaluated and need not be evaluated again.

A general procedure for the code is as follows ()

1. **Initialization**: Set n to [log2 maxi,j(ci,j)] and transmit n. Set the LSP to empty. Set the LIP to the coordinates of all the roots (i, j)€ H. Set the LIS to the coordinates of all the roots (i, j)€ H that have descendants.

2. Sorting pass:
2.1 for each entry (i, j) in the LIP do:

2.1.1 outputSn(i, j);
2.1.2 if Sn(i, j) = 1, move (i, j) to the LSP and output the sign of ci,j ;
2.2 for each entry (i, j) in the LIS do:

2.2.1 if the entry is of type A, then
outputSn(D(i, j));
ifSn(D(i, j)) = 1, then
for each (k, l)€ O(i, j) do:
outputSn(k, l);
ifSn(k, l) = 1, add (k, l) to the LSP,
output the sign of ck,l;
ifSn(k, l) = 0, append (k, l) to the LIP;
if L(i, j) not equal to 0, move (i, j) to the end of the LIS, as a type-B entry, and go to step 2.2.2; else, remove entry (i, j) from the LIS;
2.2.3 if the entry is of type B, then
outputSn(L(i, j));
ifSn(L(i, j)) = 1, then
append each (k, l) O(i,j) to the LIS as a type-A entry:
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 (the one with the same n), output the nth most significant bit of |ci,j|;

4. Loop: decrement n by 1 and go to step 2 if needed

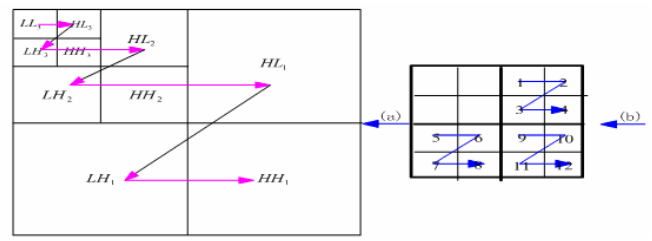

Figure 3.(a) The scanning sort of SPIHT algorithm and wavelet coefficients (b) the scanning sort of SPIHT algorithm in the same frequency band.

The SPIHT algorithm offers significantly improved quality over other image compression techniques such as vector quantization, JPEG and wavelets combined with quantization. It offers characteristics such as[11]:

- Good image quality with a high PSNR
- Optimized for progressive image transmission
- Fast coding and decoding
- Can be used for lossless compression
- Can be efficiently combined with error protection
- Ability to code for exact bit rate or PSNR.

V. CONCLUSION

JPEG 2000 and SPIHT both are lossless compression techniques but difference in their processing methodology. SPIHT is works on hierarchical tree where each leave node having the significant value on the other hand JPEG2000 is based on tiling where frequency tile or component having the significant value low. Both techniques are scene based JPEG 2000 works better where scene is complex whereas SPIHT works better where scene is smooth.

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