Image Compression using Wavelet and SPIHT Encoding Scheme

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Abstract— **The traditional image coding technology uses the redundant data in an image to compress it. But these methods have been replaced by digital wavelet transform based compression method as these methods have high speed, low memory requirements and complete reversibility. Now in this work we are considering SPIHT as a placement for wavelet compression methods. We are comparing it with wavelet encoding scheme and comparing the final results in terms of bit error rate, PSNR and MSE.**

Keywords— **Wavelet, SPIHT, Encoding, Decoding. EZW.**

I. INTRODUCTION

The discrete cosine transform *[1]* is a technique for converting a signal into elementary frequency components. It is used widely for image compression. Here we have developed some MATLAB code to calculate DCT and compress images through it.

In recent years, wavelet transform has become a much applied and researched method among mathematicians *[2], [3]*. A very important property of wavelet is its ability of frequency and time localization. Localization is the process of defining the range for total time, T, and frequency range ω that will be used in image analysis. The main difference is that wavelets are well localized in both time and frequency domain whereas the standard Fourier transform is only localized in frequency domain. The Short-time Fourier transform (STFT) is also time and frequency localized but there are issues with the frequency time resolution and wavelets often give a better signal representation using Multiresolution analysis *Walnut[4] [5]*. So wavelets transform are better than Fourier transform or DCT. So it has been utilized a lot in image processing and image compression. However, different wavelets have different merits and demerits and thus their selection is also an important criterion.

The distribution of values for the wavelet coefficients is usually centred around zero, with very few large coefficients. This implies that most of the image information is concentrated in a small fraction of the coefficients and hence they can be compresses efficiently and the computations would also be fast and small. The compression is achieved by simply quantizing the values based on the histogram and encoding the results in an efficient way by using an encoding procedure such as Huffmann coding.

In short we can summarize that the more similar the lower value coefficients are to each other, the higher compression ratio we will get. But at higher compression ratios, we will get more error. These discrepancies of wavelet method were rectified by introducing the SPIHT algorithm *[6], [7]*. This algorithm codes the most important wavelet transform coefficients first and transmits the bits so that a progressively better reproduction can be obtained over the time.

II. SPIHT ALGORITHM

A. *Description of the SPIHT Algorithm*

The SPIHT algorithm is a more efficient implementation of EZW (Embedded Zero Wavelet) [6] [8] algorithm which was presented by Shapiro. After applying wavelet transform to an image, the SPIHT algorithm partitions the decomposed wavelet into significant and insignificant partitions based on the following function:

$$S_n(T) = \begin{cases} 1, max_{(i,j)\epsilon T}\{|c_{i,j}|\} \geq 2^n \\ 0, Otherwise \end{cases}$$

Here $S_n(T)$ is the significance of a set of coordinates T, and $c_{i,j}$ is the coefficient value at coordinate (i, j). There are two passes in the algorithm- the sorting pass and the refinement pass. The SPIHT encoding process utilizes three lists

LIP (List of Insignificant Pixels) – It contains individual coefficients that have magnitudes smaller than the thresholds

LIS (List of Insignificant Sets) – It contains set of wavelet coefficients that are defined by tree structures and are found to have magnitudes smaller than the threshold.

LSP (List of Significant Pixels) – It is a list of pixels found to have magnitudes larger than the threshold (significant).

The sorting pass is performed on the above three lists. The maximum number of bits required to represent the largest coefficient in the spatial orientation tree is obtained and represented by n_{max}, which is

$$n_{max} = \left[log_2\left(max_{i,j}\{|c_{i,j}|\}\right)\right] \quad (2)$$

During the sorting pass, those coordinates of the pixels which remain in the LIP are tested for significance by using equation 2. The result is sent to the output and out of it the significant will be transferred to the LSP as well as having their sign bit output. Sets in the LIS will get their significance tested too and if found significant, will be removed and partitioned into subsets. Subsets with only one coefficient and found to be significant, will be eliminated and divided into subsets. Subsets having only one coefficient and found to be significant will be inserted to the LSP; otherwise they will be inserted to the LIP. In the refinement pass, the nth MSB of the coefficients in the LSP is the final output. The value of *n* is decremented and the sorting and refinement passes are applied again. These passes will keep on continuing until either the desired rate is reached or *n* =0, and all nodes in the LSP have all their bits output. The latter case will give an almost exact reconstruction since all the coefficients have been processed completely. The bit rate can be controlled exactly in the SPIHT algorithm as the output produced is in single bits and the algorithm can be finished at any time. The decoding process follows the encoding exactly and is almost symmetrical in terms of processing time.

B. Merits of SPIHT

SPIHT provides higher PSNR than EZW because of a special symbol that indicates significance of child nodes of a significant parent, and separation of child nodes from second generation descendants. The SPIHT algorithm depends on Spatial Orientation Trees (SOT) defined on dyadic subband structure, so some problems will arise because of its adaptation to WP decomposition. One of them is the so-called parental conflict [9] that occurs when in the wavelet packet tree one or more of the child nodes are at the lower resolution than the parent node. It must be resolved in order that SOT structure with well-defined parent–child relationships for arbitrary wavelet decomposition can be created.

III. RESULTS

IMAGE RECONSTRUCTION IN DCT METHOD

IMAGE RECONSTRUCTION USING SPIHT

	DCT	SPIHT
MSE	54.00	6.72
PSNR	30.81	39.85

So from the above table it is clear that SPIHT is a better method as it demonstrates low error (lower value of MSE) and higher fidelity (higher peak to signal ratio).

IV. ACKNOWLEDGMENT

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