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A Method for Compression of Solar Image using Integer Wavelet Transform

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Abstract*—Compression is becoming a very important method for reducing the redundancy in the images. The use of larger DWT (discrete wavelet transform) basis functions or wavelet filters produced distortion in the reconstructed image. It takes a longer compression time. This paper proposes a new technology which consist of pre-processing, IWT (integer wavelet transform), SPIHT (Set Partitioning in hierarchical trees). The integer wavelet transform reconstruct the original image without any losses. This algorithm is tested on the solar images captured by the satellite system. This experimental result shows improved compression performance, PSNR and also reduces the compression time.
Keywords*— compression, DWT (discrete wavelet transform), IWT (integer wavelet transform), and SPIHT (set partitioning in hierarchical trees).

I. INTRODUCTION

Image compression addresses the problem of reducing the amount of data required to represent an image. The underlying basis of the reduction process is removal of redundant data. The image compression is the application of data compression that encodes the original images with few bits. In image compression, three basic data redundancies are there. They are Coding redundancy, interpixel redundancy, and phychovisal redundancy. Image compression is achieved when one or more of these redundancies are reduced or eliminated. The need for compression is reducing the redundancy in the multimedia data, Reduce the storage space to save digital image in the memory and also reduce the bandwidth requirement to transmit any digital image.
There are two types' image compression techniques are available. They are Lossy image compression and Lossless Image compression. The aim of the image compression is to reduce the redundancy of the image and to store data in an efficient form. The total quality of the bit stream is less than the total data quality of original image this is called as image compression. The reason for compression of images is that the correlation between one pixel and its neighbour pixels is very high. Once the correlation between the pixels is reduced we can take the advantage of variable length coding to reduce the storage quantity.

II. METHODOLOGY

This paper proposes a new technology which consist of pre-processing, IWT (integer wavelet transform), SPIHT (Set Partitioning in hierarchical trees). This algorithm is tested on the solar images captured by the satellite system. The pre-processing block this consists of filtering and histogram equalization. The pre-processing block increases the contrast value of the input image. The proposed method SPIHT with integer wavelet transform increases the quality of the reconstructed image. It is efficient method to decompose the image and also reduces the calculation. This coding is done in mat lab version R2009a. This method increases the performance of this algorithm**.** It overcomes the drawbacks of the discrete wavelet transform.

A. Pre-processing

The pre-processing block contains filtering and histogram equalization. The pre-processing image commonly involves removing low frequency background noise, normalizing the intensity of the individual particles images, removing and masking portions of images. Image processing is the technique of enhancing data images prior to computational processing.

B. Image Filtering

The images are often corrupted by random variations in intensity, illumination, or have poor contrast and cannot be used directly. The image enhancement improves contrast values. Smoothing removes the noise. Template matching detects the known patterns. Here wiener filter is used it minimizes the mean square error between the estimated random process and desired process. Wiener filter can be used in the image processing to remove noise from a picture. It is commonly used to denoise the audio sound. The most important technique for removal of blur in images is filtering.

C. Histogram Equalization

The images with poor contrast usually contain unevenly distributed gray values. The histogram equalization is a method for increases the contrast by uniformly distributing the gray values. It enhances the quality of the image. The histogram equalization image has better contrast.

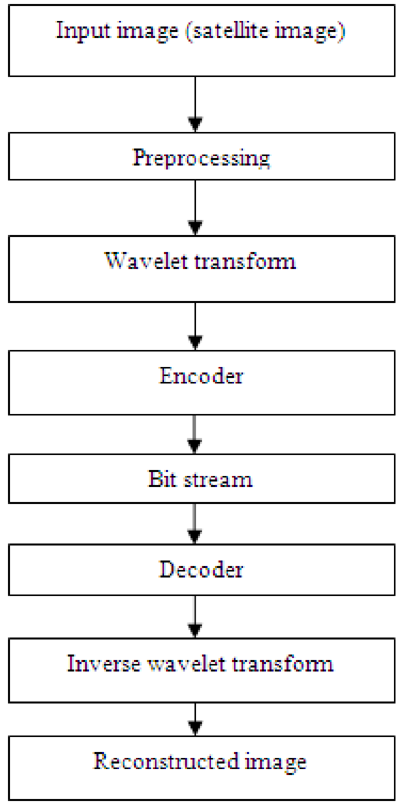

Fig.-1: Proposed Block Diagram.

III. HUFFMAN ALGORITHM WITH DISCREATE WAVELET TRANSFORM

Huffman encoding is a simple example of data compression for representing data in fewer bits. This algorithm uses the discrete wavelet transform. The wavelet is the mathematical Function that cut-off the data into different frequency components. The encoding time and decoding time for this algorithm is higher compared to the proposed method. This coding is popular technique for removing coding redundancy. The peak signal to noise ratio is lower while using discrete wavelet transform. The principle behind in the Huffman coding is variable length coding. Variable length coding is the simplest approach to error free compression. It reduces only the coding redundancy. It assigns the shortest codeword to the symbol which occurs more often and assigns longest codeword to the symbol which occurs less often.

The advantage of Huffman coding is produces shorter sequences for more frequently appearing characters; it is Simple and more efficient one. The disadvantage of Huffman coding is Code tree also needs to be transmitted as well as the message and Performance depends on good estimate. The discrete wavelet transform analysis ensures space saving coding and it's sufficient for exact reconstruction. The cost of computing DWT as compared to DCT may be higher. The use of larger DWT basis functions or wavelet filters produces blurring and ringing noise near edge regions in the images. This compression introduced ringing noise at sharp transitions which are particularly visible in text. This is due loss of high frequency component as in step response ringing. The ringing noise occurs because of loss of high frequency components or loss of precision in high frequency components. They also occur at the edge of an image. The blurred image is occurring due to camera shake. The colors of the images are also particularly lost due to low contrast. It takes longer compression time. It reconstructed the images with lower quality than JPEG at low compression ratio. The wavelets are used as basis function in representing other functions.

These basis functions are called wavelets. Wavelets are obtained from a single prototype wavelet *y (t)* called mother wavelet by dilations and shifting. Where *a* is the scaling parameter and *b* is the shifting parameter. The 1-D wavelet transform is given by:

$$W_f(a, b) = \int_{-\infty}^{\infty} x(t)\psi_{a,b}(t)\, dt$$

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The inverse 1-D wavelet transform is given by:

$$X(t) = 1/c \iint_{-\infty}^{\infty} w_f(a, b)\, \psi_{a, b}(t)\, db\, da/a^2$$

$$\text{Where } c = \int_{-\infty}^{\infty} |\psi(w)|^2/w\, dw < \infty$$

IV. SPIHT (Set Partitioning in Hierarchical Trees) ALGORITHM WITH INTEGER WAVELET TRANSFORMS (IWT)

SPIHT is computationally very fast and among the best image compression algorithms known today. This algorithm is simple and effective method .One of the most efficient algorithms in the area of image compression is the set partitioning in hierarchical tress (SPIHT). 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 where by creating a four way decomposition: LL(low pass then another low pass), LH(low pass then high pass), HL(high pass then low pass), HH(high pass then another high pass). The resulting LL version is again four ways decomposed, as shown in figure below. This process is repeated until the top of the pyramid is reached.

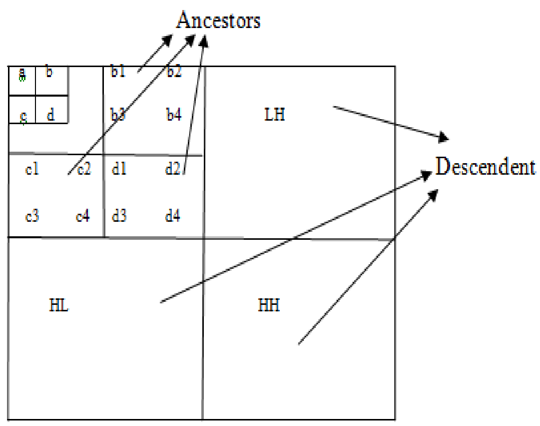

Fig-2: SPIHT (Set Partitioning in Hierarchical Trees)

SPIHT send the binary representation of integer value of wavelet coefficient. The tree is spitted into 4 parts. O (i, j) is the set of coordinates of all offspring of node (i, j).D (i, j) is the set of coordinates of all descendants of node (i, j).H (i, j) is the set of all tree roots (i, j) is the all descendents expect offspring. L (i, j) =D (i, j)-O (i, j).There are 3types of lists.

1. LSP -list of significant pixel,
2. LIP -list of insignificant pixel,
3. LSP -list of insignificant set of pixel.

A. Algorithm

Step1: First LSP is empty initial.

Step2: Process the members of LIP and LIS.

Step3: Examine each coordinates contain in LIP. If the coefficient of the coordinate is >T then the coefficient is called significant coefficient and transmit binary 1 followed by sign bit. Finally the coefficient of the coordinate moved into LSP. Otherwise transmit 0.

Step4: After examine each coordinates in LIP next examine the steps in LIS. If the set at the coordinate (i, j) is not significant transmit binary 0, otherwise binary 1 followed by sign bit. Finally move this coefficient to LSP list.

Step5: Once we process each step LIS then go to refinement process.

The integer wavelet transform (IWT) is more efficient approach to lossless compression whose coefficients are exactly represented by finite precision numbers. IWT are used to produce integer coefficients for integer encoded signals. Compared with CWT and DWT, the IWT is not only computationally faster and more memory efficient .It allows for truly lossless encoding method. The IWT can be computed starting from any real valued wavelet filter by means of a straight modification of the lifting schema. It can be able to reduce the number of bits for the sample storage and to use simpler filtering units. The IWT enables you to reconstruct an integer signal perfectly from the computed integer coefficients. To recover the original images lossless, reversible wavelet transform should be used. The IWT uses the lifting scheme.

B. Lifting Scheme for IWT

The lifting scheme saves lots of memory space and computation time. It is the fast and efficient way of finding IWT using lifting scheme. It décor relates the signal at different resolution level. It provides integer coefficients for integer encoded signals to reconstruct the original image without lossless. The lifting scheme consists of alternating lifts, that is once is low pass is fixed and the high pass is changed and in the next step the high pass is fixed and low pass is changed. The successive steps of the same direction can be merged.

In lifting scheme two operations are done.

1. Predict and
2. Update

The forward transform of lifting scheme is explained below

Detail value d_{j-1}=odd_{j-1} - predict ($even_{j-1}$).

Coarse values s_{j-1}=$even_{j-1}$ + update (d_{j-1}).

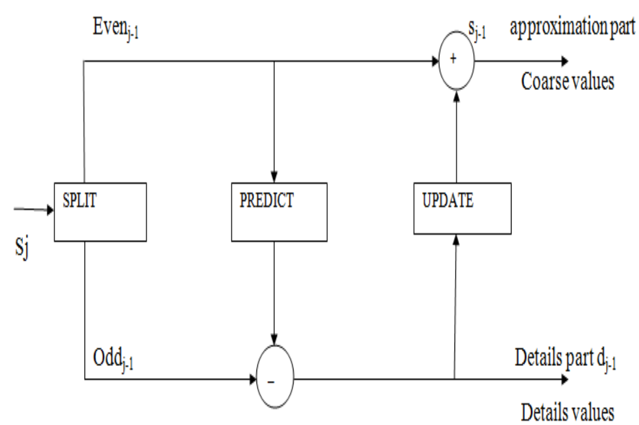

Fig-3: Forward transform of lifting scheme

The even values are updated and odd samples become the scaling coefficient. These scaling coefficients pass on to the next stage of transform. Finally the odd elements are replaced by the difference and the even elements by average.

The inverse transform for lifting scheme is explained below.

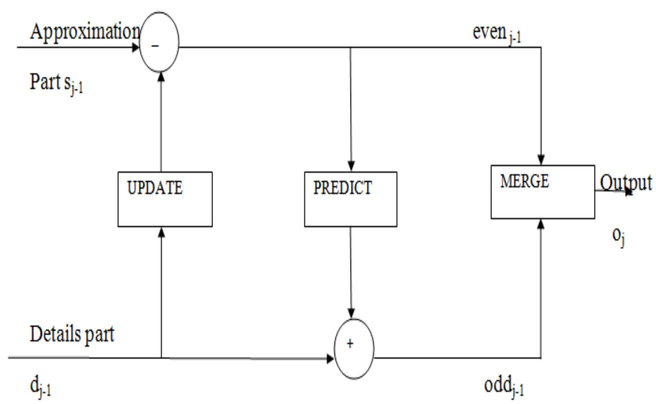

Fig-4: Inverse transform of lifting scheme

Even $_{j-1}$ =s_{j-1} - update (d_{j-1}).

Odd_{j-1}= d_{j-1} + predict ($even_{j-1}$)

o_j = s_j - merge (merge ($even_{j-1}$, odd_{j-1}).

V. SIMULATIONS RESULTS

The simulation outputs for Huffman coding with discrete wavelet transform are given below. Here the input image is a colour image. First colour image is converted into gray image. The Huffman coding reconstructed the original image without lossless. The PSNR (Peak Signal to Noise Ratio) and elapsed time is calculated. It gives low PSNR, encoding and decoding time are higher.

Fig- 5: Input image for Huffman Coding with DWT

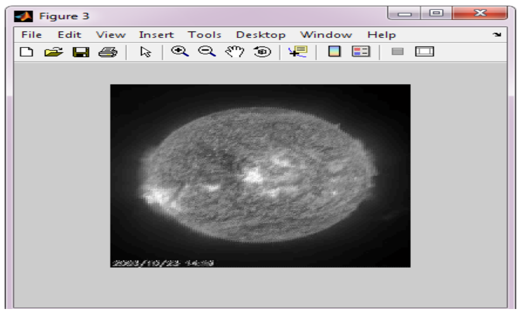

Fig- 6: output image for Huffman coding with DWT

The simulation output for SPIHT with IWT (Integer Wavelet Transform) is given below. The input for the SPIHT coding is gray image. It reconstructed the original image without any losses. The SPIHT Encoding time and Decoding time, Compression ratio (CR), Peak signal to noise ratio (PSNR) values are given below. It provides high Peak Signal to Noise Ratio (PSNR) compared to Huffman coding.

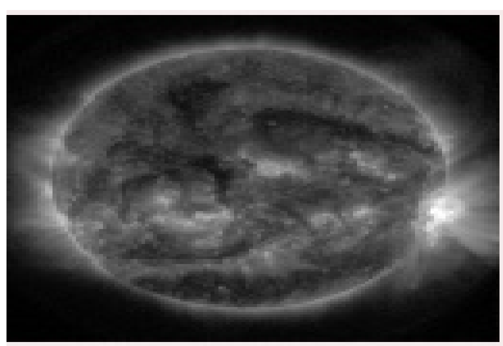

Fig- 7: Input Image

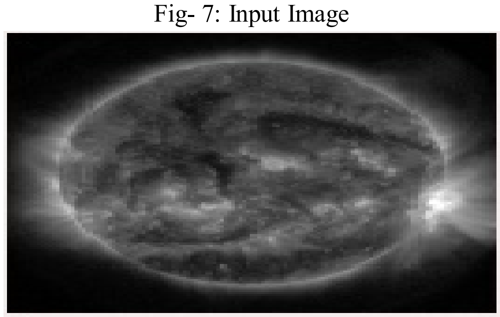

Fig- 8: Output of SPIHT with IWT

Table-1: Comparison outputs of Huffman with DWT and SPIHT with IWT

Algorithm	Encoding Time	Decoding time	CR	PSNR
Huffman with DWT	0.845sec	0.487 sec	6.77	65.89
SPIHT with IWT	0.641sec	0.307 sec	4.806	96.31

VI. CONCLUSION

The satellite image is taken as an input image. The SPIHT with IWT (integer wavelet transform) achieves the better performance than Huffman coding with DWT (Discrete wavelet transform). The integer wavelet transform achieves higher PSNR (peak signal to noise ratio) and also reduces the encoding and decoding time. The future work is focus on Block based pass parallel SPIHT Algorithm with integer wavelet transforms.

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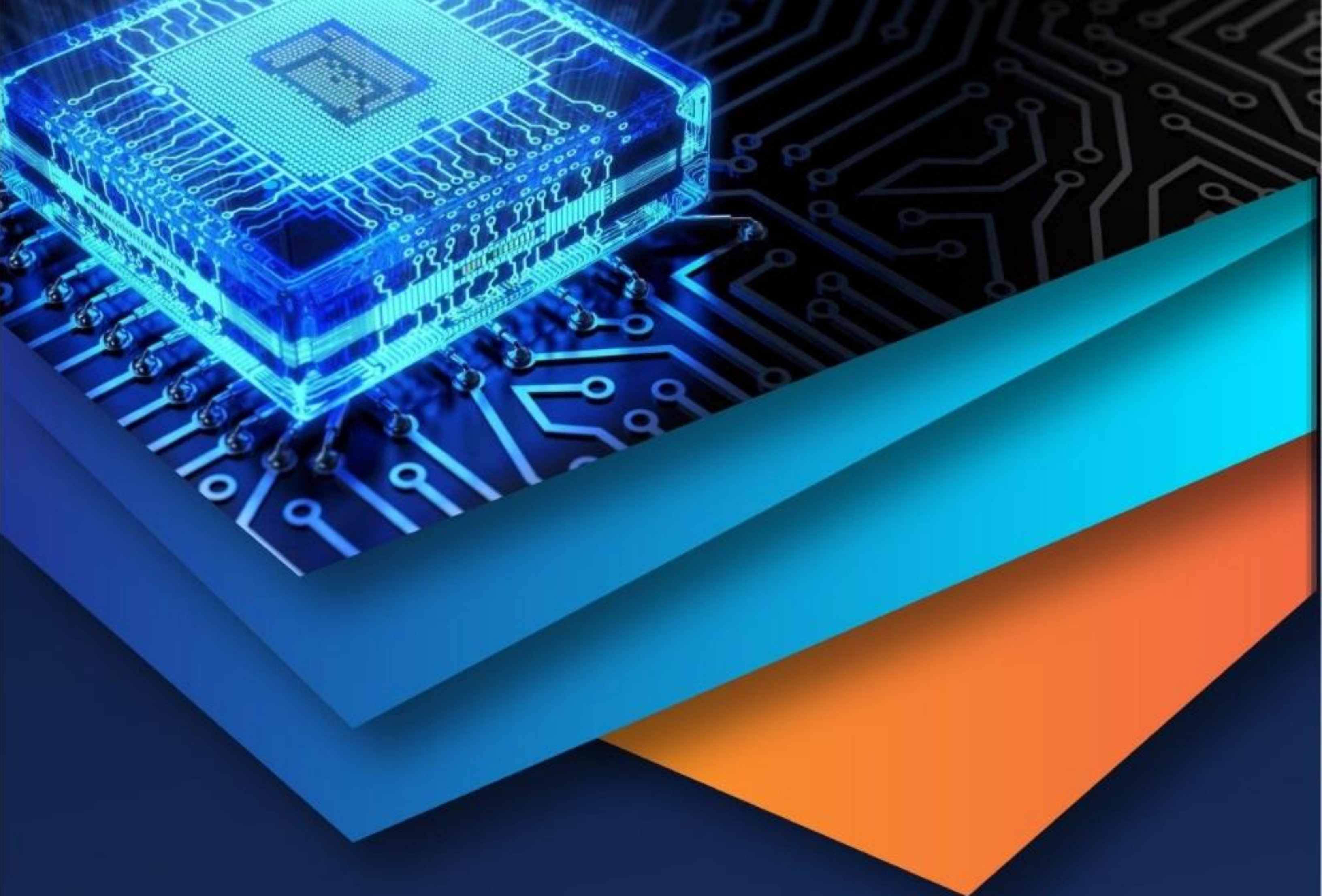

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